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ABSTRACT

The papers and research reports comprising the ten chapters of this monograph were originally prepared as background information for a national study of engineering technology education in the United States. Chapter I briefly describes the historical and contemporary settings of engineering technology education. After Chapter II provides information on the characteristics of engineering technology curricula and a tentative classification system for content areas, Chapter III illustrates the kinds of curriculum guides which appear in the catalogs of two-year institutions offering engineering technology programs. Chapter IV describes some of the characteristics of the mathematics, chemistry, and physics courses taught as part of the engineering technology curriculum. An overview is presented in Chapter V of the process of accreditation, especially in relation to the engineering technology field. Chapter VI reports on a study of engineering technology faculty, providing information about characteristics and attitudes. Chapters VII and VIII provide results for studies of the characteristics, perceptions, and activities of engineering technology students and graduates. Chapter IX considers issues related to the certification of engineering technicians; while Chapter X concludes the monograph with a statistical model projecting the future of engineering technology education. Appendices provide a list of institutions offering educational technology programs, survey instruments, enrollment estimates, and a bibliography. (AYC)

Jesse J. Defore

TECHNICIAN MONOGRAPHS:

A collection of papers and research studies related to associate degree programs in engineering technology

American Society for Engineering Education

1971

PREFACE

This book consists of a collection of papers and research reports which were originally prepared by the author as background information for the 24-man Advisory Committee of a national study of engineering technology education in the United States. This "Engineering Technology Education Study" was being conducted by the American Society for Engineering Education with support from the National Science Foundation. The project was directed by Dr. L. E. Grinter of the University of Florida; the author was assigned full-time as an assistant to the project, and was responsible mainly for investigations related to associate degree engineering technology curricula.

The original papers reached only a few readers. The documents were distributed only to the Advisory Committee and to a limited number of individuals who had participated in various ways in ASEE's Engineering Technology Education Study. These readers however, suggested that some of the information might be of wider interest, and urged that ways be sought to publish this material. Certain of the papers were subsequently condensed and published; they have appeared, for example, in *Engineering Education*. Not all, however, can be so treated, for neither space nor priority exists for the publication of some of the material. Therefore, this collection has been prepared with the anticipation that it may have some reference and interest value to the community of educators concerned with engineering technology programs.

Jesse J. Defore
June 10, 1971

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CHAPTER 1

THE AMERICAN ENTERPRISE IN ENGINEERING TECHNOLOGY EDUCATION

This paper[1] describes briefly the historical and contemporary settings of engineering technology education. It contains a brief history of the development of technological education in the United States, a review of some related developments in American higher education, a description of some of the social forces which appear to be influencing current developments in engineering technology education, and a tentative identification of current problems which relate to this sector of the educational enterprise.

The Beginning of Technological Education in the United States

Compared to liberal higher education, the roots of which in the United States reach back to the founding of Harvard in 1636,[2] technological education has a relatively brief histroy in this country. While almost all of the colonial colleges were by 1750 teaching mathematics and science, frequently including technical subjects such as surveying and navigation under the heading of mathematics,[3] it was not until 1802, with the founding of the Military Academy at West Point that appreciable attention was given to technological education; and it was not until 1824 that the first institution exclusively devoted to technological education, Rensselaer Polytechnic Institute, was founded.[4]

The world beginnings of modern technological education are only slightly more remote than those in America. The earliest date usually cited for such a "beginning" is 1766, the year of the founding at Freiburg, Germany, of a technical mining school. Some historians set the date even later: they mark a beginning either in 1775, when

[1]Portions of this paper appeared previously in another work by the same author, and have been adapted without substantial changes. See Jesse J. Defore, "Baccalaureate Programs in Engineering Technology: A Study of Their Emergence and Some Characteristics of Their Content," (Unpublished Ph.D. dissertation, Florida State University, 1966), pp.65-80.

[2]John S. Brubacher and Willis Rudy, *Higher Education in Transition.* (New York: Harper and Row, 1958), p.iii.

[3]*Ibid.*, p.17.

[4]*Ibid.*; p.61.

the French Ecole des Ponts et Chausees opened, or in 1794, when the great Ecole Polytechnique was established.[1]

The Development of Engineering Schools

After its tardy introduction to the higher education enterprise in this country, technological education eventually flourished. By the middle of the nineteenth century, a number of colleges had organized schools of engineering on their campuses: Norwich University founded a Department of Civil Engineering in 1819; Union College founded a similar department in 1845; Harvard established the Lawrence Scientific School in 1847; Yale, in 1847, began a department which later evolved into the Sheffield Scientific School; in 1852, Dartmouth and Brown founded similar schools; and in 1855, the University of Pennsylvania established a Department of Mines, Arts, and Manufacturers. The Massachusetts Institute of Technology, perhaps the most renowned of all the institutions of its type, was established in 1865.[2] The Morrill Act of 1862 greatly stimulated the founding of such institutions. By the turn of the century, some 42 engineering colleges had been established, a majority of which were receiving federal support provided by the Morrill legislation.[3] The second Morrill Act of 1890 provided additional impetus. The growth in number of such institutions has been greatly accelerated in this century. In 1969, for example, a total of 274 engineering schools were identified.[4]

The Early Development of Technical Institutes

During the same period that the Military Academy, Rensselaer, MIT, and other collegiate institutions were being founded to provide what at that time constituted advanced technological education which culminated after four years of study in the award of a baccalaureate degree, a second, distinctly different kind of educational institution was emerging also. This was the "mechanics institute." Schools of

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[1]Thomas T. Read, "The Beginnings of Engineering Education," *Journal of Engineering Education,* Vol. 30 (December, 1939), pp.348-53.

[2]Brubacher and Rudy, *op.cit.*, p.62

[3]Read, *loc.cit.*, p.351

[4]John D. Alden, "Engineering and Technician Enrollments, Fall 1969," *Engineering Education,* September-October, 1970, pp.31-47.

this type were founded mainly in eastern and mid-western industrial centers, and made their first appearance during the 1820's. Although their purposes were greatly dissimilar from those of the schools which today offer programs in engineering technology, these early institutions may be regarded as the precursors of technical institutes. These schools offered courses in mathematics, bookkeeping, surveying, navigation, and other vocational subjects; they sought the "promotion of the useful arts;" they trained artisans and draftsmen. They attempted to provide training to meet the manpower needs of an expanding industrial economy for draftsmen, supervisors, designers, production workers, and other technical personnel which neither the secondary schools nor the engineering colleges were meeting directly at that time.[1] The first of these was the Gardiner Lyceum, in Gardiner, Maine, established in 1822.[2] This school, however, ceased to operate after ten years. Most of the early institutes suffered a similar fate. Only one, the Ohio Mechanics Institute, established in 1828 in Cincinnati, is still in existence;[3] it operates now under the name of the Ohio College of Applied Science as a part of the University of Cincinnati.[4] The spread of free public education is cited as a cause for the rapid waning of interest in these schools.[5] Later in the century, a revival of interest in such institutions occurred, due largely to spreading industrialization. Spring Garden Institute, now named Spring Garden College, was founded in 1851 in Philadelphia, and serves as an example of the many such schools formed as a result of the industrial needs of the mid-1800's. Pratt Institute in Brooklyn, New York, was established in 1877 as an institution of this type, but it gradually changed into a traditional engineering school.[6] The Rochester Institute of Technology, formerly, the Rochester Athenaeum and Mechanics Institute, has a similar history.[7] According to Graney, there were "dozens of such

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[1]Leo F. Smith and Laurence Lipsett, *The Technical Institute* (New York: McGraw-Hill Book Co., Inc., 1956), pp.18-20.

[2]William E. Wickenden and Robert H. Spahr, *A Study of Technical Institutes* (Lancaster, Pennsylvania: Society for the Promotion of Engineering Education, 1931), p.4.

[3]Smith and Lipsett, *op.cit.*, p.20.

[4]Ohio College of Applied Science, *Bulletin*, 1965-66.

[5]Smith and Lipsett, *op.cit.*, p.19.

[6]*Ibid.*, p.22.

[7]*Ibid.*, p.23.

institutions started during the late nineteenth and early twentieth centuries."[1] These "flourished for a period of time and then disappeared from the scene."[2] Other than the Ohio College of Applied Science and Spring Garden College, only a few, notably the Milwaukee School of Engineering (founded 1903), the Franklin Institute of Boston (1908), and Wentworth Institute (1911), still survive. Graney characterized these institutions:

> They geared their instruction to the maturing technology of the time, laying emphasis upon application with intensive instruction during short periods of less than four years. If they tended to prepare artisans, at least to some degree, it was because such artisans as they prepared were qualified, themselves, to bridge the gap between practice and theory.[3]

Development of Community Junior Colleges

Community junior colleges, especially in recent years, have made important contributions to the domain of technological education.

Junior colleges first appeared as identifiable institutions during the mid-1800's. Bogue, for example, reported that "... Lasell Junior College, Auburndale, Massachusetts, offered two years of standard collegiate instruction, as early as 1852."[4] A dozen or so similar institutions, both private and public, were established during the last half of the nineteenth century; few of these, however, have survived.[5] The stated objectives of the early institutions was to provide lower division university studies for transfer or general education purposes. After the turn of the century, the junior college movement prospered and the number of junior colleges increased until in 1921 there were 207 such institutions, 70 public and 137 private.[6] It was in the 1920's that the concept of occupational education as an integral part of the junior college curriculum

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[1]Maurice Graney, *The Technical Institute* (New York: Center for Applied Research and Education, 1965), p.9.

[2]*Ibid.*

[3]*Ibid.*

[4]Jesse Parker Bogue (ed.), *American Junior Colleges*. Fourth Edition, 1956, (Washington American Council on Education, 1956), p.2

[5]The oldest public junior college still in existence is at Joliet, Illinois, and was founded in 1901.

[6]James W. Thorton, Jr. *The Community Junior College* (New York: John Wiley and Sons, Inc., 1960), p.50.

received substantial acceptance, although this concept of institutional role had been enunciated earlier by some of the leaders of the junior college movement.[1] The number of "terminal courses," as they were titled, grew from 100 in 1921 to 400 in 1925, 1600 in 1930, and more than 4000 in 1940.[2] The wider role of the junior college as a *community* institution, relating directly to the total educational needs of the local area, became fixed during the decade of the 40's; the 1948 Report of the President's Commission on Higher Education, *Higher Education in American Democracy*, described these institutions formally in language which emphasized their community-centered nature.[3]

The evolution and maturation of the community college philosophy, acceptance of these institutions by the public, federal and state interest in this kind of education, and the burgeoning enrollments in higher education are all factors which have contributed to the growth of community junior colleges. The data in Table 1 indicate the trends.

In the past ten years, the growth rate has been particularly spectacular. About fifty new colleges have opened each year, and these new colleges have uniformly shown substantial enrollment increases during their second year of operation.

TABLE 1.--Number of Community Junior Colleges and Total Enrollments for Selected Years, 1900 - 1970.

School Year	Total Number of Colleges	Total Enrollment
1900 - 1901	8	100
1921 - 1922	207	16,031
1938 - 1939	527	196,710
1952 - 1953	594	560,731
1958 - 1959	677	905,062
1967 - 1968	993	1,954,116
1969 - 1970	1,036	2,186,272

[1]See, for example, Alexis F. Lange, "The Junior College as an Integral Part of the Public School System," *School Review*, September, 1917 pp.465-79.

[2]Merton E. Hill, "History of Terminal Courses in California," *Junior College Journal*, February, 1942, pp. 311-13.

[3]President's Commission on Higher Education. *Higher Education for American Democracy*. A Report. (New York: Harper and Brothers, 1948), Vol. I, Ch. 4; Vol. III, Ch. 2.

Nearly 90 percent of all American community junior colleges offer occupational education programs. Such programs vary widely in objective, level, nature of clientele served, and other characteristics. All community college occupational programs, however, are intended to prepare students for immediate gainful employment upon graduation. Engineering technology curricula are often included in community college offerings. In 1968, for example, the American Association of Junior Colleges reported that approximately 300 institutions offered organized curricula in engineering technology or a closely related field. Such engineering technology programs lead to the award of associate degrees.

Community colleges also may offer occupational programs which are post secondary and have a vocational emphasis, but which lead to the award of certificates rather than degrees. Often, both associate degree programs and certificate programs may be offered at the same institution. It is estimated that approximately 210,000 students were enrolled in associate degree curricula in 1968; at least twice that number were enrolled in non-degree programs.[1]

The Emergence of Baccalaureate Technology Programs

Very recently, a new stream of technological education has emerged, namely, the *four-year* program in engineering technology. While two-year technology programs have a history extending over half a century, being associated with both technical institutes and community colleges, the concept of a four-year curriculum is a contempory development. An early allusion to the idea came in 1957, when J. C. Elgin, of Princeton wrote in *The Engineer:*

> We should expand the numbers of people trained at the technician level. This can be done through the development of the technical institute, by increasing the number of such two-year--or even four-year--technical institutions, and by stressing the recognition by industry as engineer-technicians and engineering aides, of those so trained.[2]

In June 1965, Harold A. Foecke, then Specialist for Engineering Education, United States Office of Education, stated that more than sixty colleges were offering four-year technology curricula.[3] A 1966

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[1]Extrapolated from data by the U.S. Department of Health, Education, and Welfare, Office of Education, *Digest of Educational Statistics, 1968* (Washington: U.S. Government Printing Office, 1968).

[2]J. C. Elgin, "The Dean's Page," *The Engineer,* December, 1957.

[3]Harold A. Foecke, "Engineering and Technology," address before members of the Technical Institute Division, American Society for Engineering Education, June, 1965, (Unpublished.)

study[1] identified 73 institutions which purported to offer baccalaureate engineering technology programs or programs in "an industrial technology closely allied to the engineering field."

A number of forces appear to have encouraged the inauguration of baccalaureate technology curricula.[2] As professional engineering education tends to vacate the undergraduate level in favor of graduate level programs, the existing two-year programs in engineering technology are tending to be "stretched from above" to fill the educational vacuum created. Furthermore, the two-year technology programs at technical institutes are "bulging from within" as more and more subject matter is added to the curriculum. And at the same time, many community colleges and area vocational schools are conducting certificate level programs which sometimes compete with engineering technology programs of associate degree level, and hence are "nudging from below." Industry has often urged establishment of baccalaureate technology programs; such encouragement has provided an appreciable impetus for inauguration of such four-year curricula. Grant Venn has written of an "upward push" due to complexity of industrial enterprise as follows:

> Now, technology has advanced many occupations on the technical, skilled, and semi-professional levels to a point where they require higher levels of specialization and related knowledge that are best learned within educational frameworks. Manifestations of this upward push are to be found, for example, in engineering, where the two-year engineering technology curricula of today compare in vigor and breadth with the four-year engineering curricula of twenty-five years ago. As engineering continues to become more complex and specialization is delayed, graduate study will become a must for the engineer, and, by the same token it is probable that within the present decade the bachelor's degree will become a must for many technical occupations.[3]

There are also parental, peer group, and societal pressures for individuals to obtain baccalaureate degrees as a matter of personal or family prestige.[4]

Parallel to the "stretch," "bulge," "nudge" and "push" which have been perceived as tending to encourage a vertical extension of two-year engineering technology programs, there are significant

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[1]Defore, *op.cit.*

[2]*Ibid.*, pp.76-80

[3]Grant Venn, *Man, Education and Work* (Washington: American Council on Education, 1964), p.17.

[4]Graney, *op.cit.*, pp.103-109.

developments in other areas of higher education. Colleges, schools, and departments of industrial education and industrial arts have devised curricula which are intended to provide students with routes to industrial employment rather than to teaching. Such programs are usually called "industrial technology" in the lexicon of the institutions which offer them.

The first of such Industrial Technology programs was reported in 1923 at Bradley University; a second was reported in 1932 and a third in 1944. By 1960, 33 programs were established; three years later, one researcher reported 53 such programs.[1] Currently, 94 are identified,[2] and more are projected. A number of newly founded institutions, in particular, seem inclined to inaugurate such programs as part of their initial offerings, and many institutions are restructuring their industrial education units to dissociate the industrial technology program from the teacher education program.[3]

Educators and employers having interest in industrial technology education have formed an organization to deal with matters related to the area. This organization, the National Association for Industrial Technology, was founded in 1968, and is directing professional attention (including accreditation efforts) toward the unification and articulation of the more than 90 such programs as now exist.

Current Issues

Enrollment Trends

One of the most crucial of the current issues in engineering technology education is an apparent relative decrease in its ability to attract student enrollment. The 1968 survey of enrollments conducted by the Engineering Manpower Commission revealed that enrollments in two-year, associate degree programs at the institutions having one or more curricula accredited by ECPD were three percent

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[1] Nelson A. Hauer, "Status Study, Industrial Technology," Newsletter from College of Agriculture, School of Vocational Education, Louisiana State University, Baton Rouge, Louisiana, November, 1966. (Processed.)

[2] Gene Stuessy, "The Scope of Industrial Technology Programs in Terms of Number of Students and Curriculum Options Available." Report of a Survey, National Association of Industrial Technology, February 20, 1970.

[3] See, for example, *Industrial Arts/Industrial Technology*, Office of the Chancellor, Division of Academic Planning, The California State Colleges, February, 1970.

lower than in 1967.[1] Both full-time and part-time enrollments were down. These results were particularly disappointing in that 12 more schools were listed in 1968 than the year before. In 1969, an increase in technology enrollments was reported, but the data were difficult to interpret.[2] Both engineering enrollments and engineering technology enrollments have remained relatively static since 1958. Total higher education enrollments, on the other hand, have increased steadily, rising from 3.4 million in 1958 to 8.0 million in 1969.[3] The relative position of engineering and engineering technology, thus, has slipped appreciably. As a result, the already serious long-term shortages of technological manpower are projected to become critical.

Criteria for Accreditation

Additional issues of some urgency are those related to accreditation.[4] The criteria now being used by ECPD in the accreditation of engineering technology curricula at both the two-year and four-year levels were developed in the early sixties.[5] Changes in engineering education, in engineering practice, in engineering technology education, in manpower utilization practices as related to technician employment, and in the general nature of the technological environment all indicate that the criteria now in use should be subjected to critical review. It is especially important that appropriate criteria for four-year programs be developed.

Delineation, Articulation and Coordination

A third set of issues of importance in engineering technology education is related to a clear delineation of the role and scope of this form of higher education and its articulation with other

[1]Engineers Joint Council, Engineering Manpower Commission, *Engineering and Technician Enrollments, Fall 1968.* (New York: The Council, 1969), p.117.

[2]Alden, *loc.cit.*, p.32.

[3]U.S. Department of Health, Education, and Welfare, Office of Education, Projections of Educational Statistics to 1977-78, 1968 Edition. (Washington: U.S. Government Printing Office, 1969), p.12.

[4]Because of the relevance of accreditation matters to the engineering technology education study, chapter 5, herein, is devoted to this subject.

[5]American Society for Engineering Education, *Characteristics of Excellence in Engineering Technology Education* (Urbana, Illinois: The Society, 1962).

sectors of the educational enterprise. It is important, for example, that the differences between engineering technology education and engineering education be understood. It is equally important that the differences and commonalities between engineering technology programs and other technical education programs be made clear. And it is highly important that articulation and coordination be achieved among institutions offering these various programs in order that students be given maximum educational opportunity and that the general public be protected from the financial burden of supporting a variety of institutions with ambiguous or overlapping purposes. At the same time, the higher education community should feel constrained to assume the responsibility for providing adequate routes of preparation to meet the manpower needs of contemporary society.

Summary

Technological education in the United States has little more than a century of heritage. Evolving principally from schools of applied science, mechanics institutes, and similar prototypes, contemporary technological education is conducted in various institutional settings, each having a unique history. The education offered is as diverse as the characteristics of the institutions which offer it, and the form of the educational process has undergone numerous transitions throughout the history of the movement; this is especially true of engineering technology education.

A number of social forces are currently at work. The changes occurring in engineering education, the trends to extend vertically two-year engineering technology programs, the proliferation of community colleges, the emergence of industrial technology programs, and the changes in the technological environment itself are all factors which are serving to give new directions for the evolution of engineering technology education.

Current issues needing resolution include problems related to enrollment, accreditation, delineation of the role and scope of engineering technology education, and articulation within the educational community.

CHAPTER 2

SOME CHARACTERISTICS OF ASSOCIATE DEGREE CURRICULA IN ENGINEERING TECHNOLOGY

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SOME CHARACTERISTICS OF ASSOCIATE DEGREE CURRICULA IN ENGINEERING TECHNOLOGY

This paper describes briefly some characteristics of curricula in engineering technology which exist in various educational institutions in the United States and which lead to the award of associate degrees. It provides a tentative classification system by which content areas can be identified, presents an analysis of various curricula, compares curricula as they exist in different kinds of institutional settings, and points out some implications of the study which was made.

Population

Kinds of Institutions

Institutions which offer educational programs leading usually to the award of associate degrees in engineering technology are of various types. A seven-fold classification system is useful. Kinds of institutions may be identified as follows:

1. Single purpose institutions having engineering technology education as their sole institutional objective; the term *monotechnical institutes* will be adopted in this paper to describe such schools.

2. Institutions with a variety of objectives related to technical and occupational fields, including programs related to business, health, and public service as well as to engineering; the term *polytechnical institutes* will be used here to designate these institutions.

3. Community and/or junior colleges which include an occupational-technical program as well as a liberal arts, "university parallel," "transfer" program; such colleges will be referred to as *comprehensive community colleges*.

4. Universities or other senior institutions which include associate degree programs in engineering technology as part of their offerings, either on the main campus or at a branch campus; these, regardless of the actual name of the institution, will be called *universities*.

5. Special educational units set up with a company organization to provide educational experiences for inservice or preservice employees; the term *company schools* will be used in reference to this kind of unit.

6. Army, navy, air force, or other military service schools devoted to engineering technology education; such units will be called *service schools*.

7. Institutions which provide home study materials so that individuals can complete a program of study by correspondence; these will be called *correspondence schools.*

A substantial majority of the activity in engineering technology education occurs in monotechnical institutes, polytechnical institutes, comprehensive community colleges and universities. While the importance of company schools, service schools and correspondence schools and the value of their contributions cannot be denied, it is within institutions of the first four types that engineering technology education mainly occurs.

Size of Population

It is extremely difficult to establish an accurate inventory of the curricula with which this paper is concerned. The literature and the various published directories give widely differing estimates of the size of the population. Several factors may account for discrepancies which have been found:

1. The term "engineering technology" is not uniformly defined.

2. The term "associate degree," while adequately defined, is often used in a context such as "...associate degrees or equivalent awards...," a practice which tends to contaminate statistics based on the degree.

3. Changes in the structure of institutions, the founding of new institutions, and name changes of older institutions result in both duplications and omissions from directory lists.

4. Time lags between the collection of data and its publication create discrepancies.

5. Institutions often report as "curricula offered" all programs appearing in the published catalog, regardless of whether the curricula actually have enrollments.

6. Multicampus institutions, especially, report data in differing ways; for example, some institutions report separately the curricula which are replicated at different campuses or branches while other institutions report one curriculum only.

Published directories are useful only in making tentative estimates. For example, one recent publication[1] lists over 5000 curricula offered by some 830 institutions, but not all the curricula listed lead to associate degrees. Another directory[2] contains over

[1] *Career Opportunities; Engineering Technicians,* J.G. Ferguson Publishing Company, Chicago, Illinois: 1969. (One volume in the series *Career Opportunities for Technicians and Specialists;* Walter M. Arnold, Series Editor; Walter J. Brooking, Volume Editor.)

[2] *Technician Education Yearbook, 1969-70,* Prakken Publications, Inc., Ann Arbor, Michigan : 1969.

1200 institutional names but includes among its listings some secondary schools as well as higher institutions. Neither reference is entirely reliable and each overestimates the population.

The standard source of directory information for institutions of higher education, the U.S. Office of Education's *Educational Directory*, is of little assistance, for it does not identify in sufficient detail the kinds of curricula offered.[1]

Two recent publications, however, are useful. In 1969, the Engineering Manpower Commission conducted a survey of degrees awarded in technology. The report of this survey[2] stated that 394 institutions had made associate degree awards during the 1968-69 year. There is some evidence that this is a low estimate, for a number of the institutions which had responded to a similar EMC survey in 1968 did not report in 1969.[3] The EMC data also suffer from confusion in reports from multicampus institutions. The National Center for Educational Statistics of the U.S. Office of Education furnishes one additional clue to the size of the population. A publication issued in 1969 and based on the 1967-68 academic year suggests that approximately 450 institutions made "formal awards" to students completing programs "at the technician or semiprofessional level."[4] The NCES data, again, is believed to underestimate the population, since many of the institutions which did report to EMC in 1969 had not reported to NCES in 1968.

The union of the set of institutions reporting to EMC with the set reporting to NCES is believed to produce a list of acceptable accuracy. Such a union contains 563 institutions. A similar operation to estimate the number of curricula offered yields a value of 1595; this figure, however, is probably less valid than the previous one, since some differences exist in curriculum classification practices by EMC and NCES.

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[1]See, for example, *Educational Directory, Higher Education, 1969-70*, U.S. Government Printing Office, Washington: 1970.

[2]John D. Alden, "Technology Degrees, 1968-69," *Engineering Education*, January, 1970, pp. 410-415.

[3]*Ibid*, p.410.

[4]National Center for Educational Statistics, *Associate Degrees and other Formal Awards below the Baccalaureate, 1967-68*, U.S. Government Printing Office, Washington: 1969. See especially Table 7, pp.43-62.

Nature of Population

Table 2 contains in summary form some observations about the characteristics of the approximately 560 institutions which offer nearly 1600 different associate degree curricula in engineering technology.

TABLE 2.--General Characteristics of Institutions which offer Associate Degree Engineering Technology Curricula

Item	Comments
Control	86% public, 14% private
Type	87% are two-year institutions 13% are universities or four-year colleges which include associate degree curricula in their offerings
Emphasis	10% offer engineering technology only 13% offer a variety of technical programs but deal only in technical education 64% are comprehensive community colleges 13% are senior colleges or universities
Accreditation	11% have at least one curriculum accredited by the Engineers' Council for Professional Development 92% are accredited by the appropriate regional accrediting association
Extent of Offerings	80% offer four or fewer engineering technology curricula 20% offer more than four engineering technology curricula
Popularity of Offerings	Electrical/Electronics Technology is offered most frequently (30% of the total curricula, 50% of the institutions, and 25% of the associate degrees awarded) Mechanical Technology is second in frequency of offering (12% of the total curricula, 25% of the institutions, and 13% of the associate degrees awarded)

Curriculum Characteristics

Conceptual Framework

Engineering technology curricula, although they may differ from one another in certain respects, are expected to have many characteristics in common. An analysis of existing curricula should reveal some major patterns of commonality and should suggest ways in which curricula can be distinguished. The patterns of contemporary practice, in turn, might suggest goals for future evolution of such curricula.

Based on such a conceptual framework, a curriculum analysis was undertaken. Preliminary investigation had suggested that three variables would be of major usefulness in such an analysis of engineering technology curricula:

1. Institutional setting
2. Curriculum Structure
3. Technical discipline of curriculum

For analysis purposes a curriculum's "institutional setting" was defined as the *kind* of institution--monotechnical institute, polytechnical institute, comprehensive community college, etc.--in which the curriculum was found; the "curriculum structure" was a profile of the required credit hours in various curricular areas; and the "technical discipline" was the major emphasis of the curriculum, that is, the area of specialization (drafting, electronics, highway construction, etc.) on which it concentrated.

Two additional variables, "accreditation by the Engineers' Council for Professional Development" and "topic coverage in selected areas" were initially expected to be somewhat useful in discrimination of curricula. The "accreditation" variable is treated here; the "topic coverage" variable has been treated separately.

A number of other possible variables existed but were rejected because it was believed they possessed limited relevance. Such variables included control (private vs. public), age of curriculum, enrollment in curriculum, age of institution, credit basis (semester, quarter, other), location of institution (urban, rural), and others.

Procedure and Sample

A sample of 120 engineering technology curricula were chosen and subjected to analysis. This was essentially an *arbitrary* sample. It does not have--nor was it intended to have--the statistical properties of randomness, stratification, or representativeness. Rather, the curricula selected were ones judged likely to have influence--past or future--on the trends in engineering technology education.

The curriculum study was made principally by means of examining the published catalogs and bulletins of various institutions, although 19 of the institutions involved were personally visited by the author.

In the sample, 71 of the curricula were accredited by ECPD.

The distribution by discipline of the curricula in the sample is indicated in Table 3.

The classification of curricula in the sample by institutional setting is given in Table 4. The original intent had been to provide for approximately 30 members of each category, an objective satisfactorily achieved. However, preliminary study showed that university programs--because of their assignment to separate branches, campuses, departments or other instructional units--resembled closely

TABLE 3.--Curriculum Titles in a Sample of 120 Associate Degree Engineering Technology Curricula

Approximate Curriculum Title	Number
Aeronautical	4
Air Conditioning	3
Architectural (including building construction)	13
Chemical	8
Civil (including surveying, highways)	18
Drafting/Design	8
Electrical	7
Electronics	21
Industrial (including manufacturing)	7
Mechanical	18
Metallurgical (including materials)	4
Other (automotive, computer, petroleum, fire protection, nuclear)	9
TOTAL	120

TABLE 4.--Institutional Settings of the Curricula in a Sample of 120 Associate Degree Engineering Technology Curricula

Kind of Institution	Number of Curricula
Monotechnical Institutes	24
Polytechnical Institutes	35
Comprehensive Community Colleges	28
Universities	33
TOTAL	120

the programs in either monotechnical institutes or polytechnical institutes. A reassignment of the 33 curricula in universities resulted in the distribution shown in Table 5; this grouping was used

TABLE 5.--Groupings Used in the Analysis of a Sample of 120 Associate Degree Engineering Technology Curricula

Kind of Institution	Number of Curricula
Monotechnical Institutes	54
Polytechnical Institutes	38
Comprehensive Community Colleges	28
TOTAL	120

through the analyses conducted. Although the cells are unbalanced as a result of the regrouping, the internal variance in each cell is virtually unaffected.

The sample was taken approximately equally from the various geographic regions of the United States. Table 6 shows the geographic distribution of the sample. While the northeastern region is somewhat over-represented in the sample, this region also possesses a disproportionately high fraction of the total institutional population which is engaged in engineering technology education. The distribution is deemed satisfactory for these purposes.

TABLE 6.--Geographic Distribution of a Sample of 120 Associate Degree Engineering Technology Curricula

Geographic Region	Number of Curricula
Northeast	34
Southeast	18
North Central	30
South Central	20
West	18

The results of the analysis are given in a later section of this paper.

Definitions

For the purposes of this paper, the following definitions related to curriculum content are adopted:

Technical specialty--technological subject matter content in an engineering technology curriculum in which a student concentrates study; the "major" of a curriculum. For example, technical specialty subject matter in an electrical technology program usually will include college courses entitled "electrical machinery," "transmission networks," "microwaves," and the like.

Related technical studies--technological subject matter content in an engineering technology curriculum related to some area of technology or to the development of skills to support a technology, but which is not directly related to the specialty of the curriculum. For example, related technical studies in an electrical technology curriculum might include college courses entitled "engineering drawing," "manufacturing processes," "industrial materials," or the like.

Technical sciences--subject matter content in an engineering technology curriculum involving basic mathematical and/or scientific principles applied to technical problems and situations. Derived from the "pure sciences", the technical sciences may include such areas as statics, dynamics, strength of materials, fluid mechanics, thermodynamics, statistics, electric theory, and properties of matter. The "technical sciences" of an engineering technology curriculum are analogous to the "engineering sciences" of an engineering curriculum.

Physical sciences--chemistry, physics and integrated courses in chemistry and physics.

Mathematics--subject matter content beyond the level of "intermediate algebra", that is, "college algebra" and other mathematics subjects including trigonometry and calculus which have college algebra as a co- or pre-requisite.

Communications--subject matter content related to grammar, rhetoric, speech writing, and other phases of language, except literature, and requiring four high school units in English as a pre-requisite.

Humanities/Social Studies--subject matter content related to literature, the arts, philosophy, psychology, history, sociology, political sciences, and the like.

Other studies--subject matter content in a curriculum not classifiable under one of the preceding categories; these include R.O.T.C., physical education, life science, foreign language, and "free electives" not identifiable by category.

A "Typical" Engineering Technology Curriculum

The sample of 120 engineering technology curricula examined displayed patterns of similarity, although some variance was detected. Table 7 summarizes the major curriculum characteristics of these programs in terms of semester hour credits required in various curricular areas. The range, the mean (adjusted to the nearest half-credit), and the mode of the required credits are reported.

As can be noted from Table 7, the requirements in each curricular area had considerable apparent variation. Part of this variation is real and is to be expected, due to the differences in program objectives at different institutions. On the other hand, some of the variation is artificial and was introduced by the classification scheme used in this study. For example, the introductory courses in Chemistry which appeared in the Chemical Technology programs analyzed were classified as "physical sciences" rather than "technical specialties;" such classification procedures *per se* contributed to the low extreme in the range of requirements in the "technical specialty" area and the high extreme in the "physical sciences" category as shown in the table.

TABLE 7.--Curriculum Characteristics of a Sample of 120 Associate Degree Programs in Engineering Technology

Curricular Area	Semester Credits Required		
	Range	Mean[a]	Mode
Technical Specialty	8-42	23	24
Related Technical Studies	0-22	8	8
Technical Sciences	0-22	7	8[c]
Physical Sciences	4-18	7	8
Mathematics	4-14	8.5	10[d]
Communications	3-12	6	6
Humanities/Social Studies	0-15	7	6
Other	0-14	2	2
Total Technical Studies[b]	24-51	39	40
Total Curriculum	60-83	71	72

[a]Adjusted to nearest half semester credit; for computed values, see Table 8.

[b]Includes technical specialty, related technical studies and technical sciences.

[c]High frequencies at 0 and at 4 semester credits were also noted.

[d]High frequency at 6 semester credits was also noted.

The histograms of Figure 1 give some insights into the variations and central tendencies which were found.

Table 8 summarizes some relevant statistical properties of the data used. In Table 8, a "computed mean" is the result of a numerical calculation, to the nearest tenth of a semester credit, of the mean of the data being analyzed; this is a stable statistic which is useful for making comparisons within the data base, but is not especially meaningful descriptively. The "adjusted mean," a value rounded to the nearest half-credit, is more useful as a nominal value. The standard deviation has the usual meaning of that statistic. "Relative variability" as reported in the table is a statistic which gives an indication of the extent to which data are clustered about their mean; it is a rough measure of kurtosis. In this situation, a relative

FIGURE 1.--DISTRIBUTIONS OF SEMESTER CREDIT HOUR REQUIREMENTS IN VARIOUS CURRICULAR AREAS FOR 120 ASSOCIATE DEGREE ENGINEERING TECHNOLOGY CURRICULA

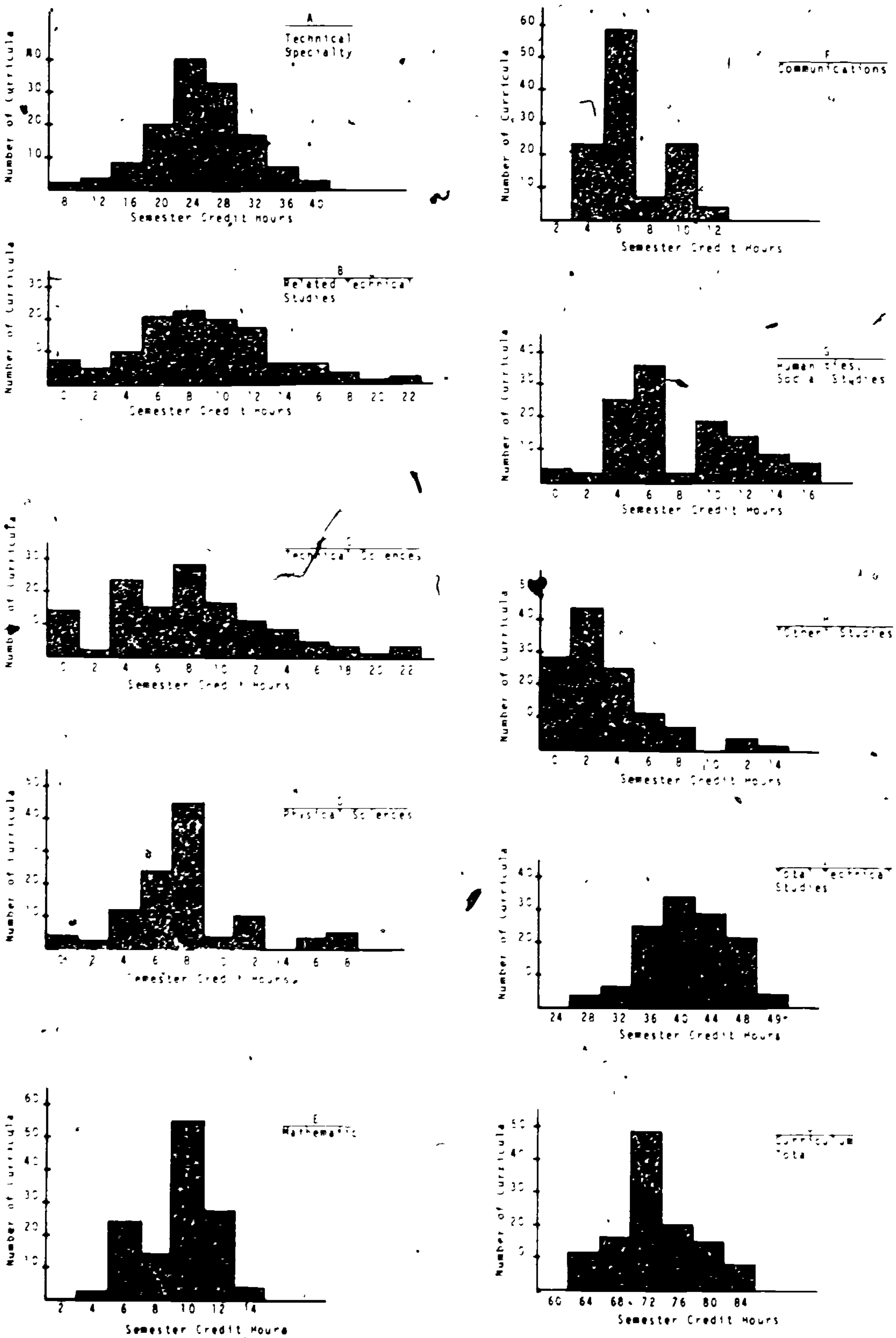


TABLE 8.--Statistical Characteristics of Data Used in Development of a "Typical" Associate Degree Engineering Technology Program from a Sample of 120 such Curricula

	Computed Mean[a]	Adjusted Mean[a]	Standard Deviation[a]	Relative Variability[b]	Conformal Limits[a]
Technical Specialties	23.2	23	5.52	23.8	1.8
Related Tech. Studies	7.8	8	4.62	59.2	1.5
Technical Sciences	6.7	7	4.70	70.0	1.5
Physical Sciences	6.9	7	3.08	44.7	1.0
Mathematics	8.5	8.5	2.20	25.8	.7
Communications	5.9	6	2.24	38.0	.7
Humanities/ Social Studies	6.7	7	4.00	60.0	1.3
Other	2.1	2	3.94	185.7	1.3
Total Technical Studies	39.1	39	5.44	14.0	1.8
Curriculum Total	71.1	71	6.68	9.4	2.3

[a]In semester credits

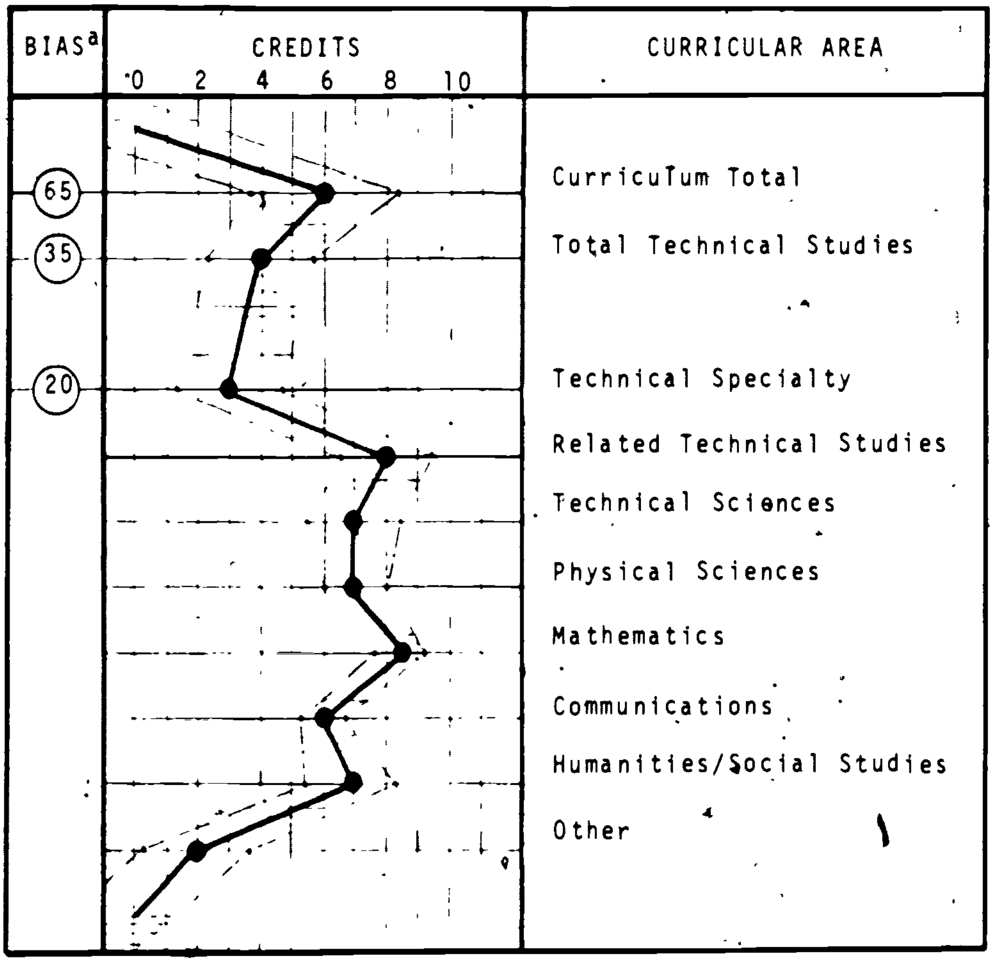
[b]In percent

variability less than 25 percent implies a significantly leptokurtic distribution (one more peaked than the "normal" distribution) having the mean value itself occur frequently in the data. A relative variability near 50 percent is associated with data having a multimodal distribution (as in the case of "Communications," where a distinct bimodal pattern is observed). A relative variability exceeding 100 percent (as in "Other," Table 8) is associated with data having an extremly platykurtic distribution or lacking any appreciable central tendency at all. For data with relative variability exceeding about 35 percent, the strongest mode is probably a better representation of practice than is the mean.

The "conformal limits" reported in Table 8 are statistics which will be useful in the profile analysis to be made later in this paper. It has been assumed that the sample of 120 curricula form a whole-set of data comprised of several differing subsets. Each subset presumably will have data means which *conform* or not to the data means of the whole-set. The range around the whole-set mean through which a subset mean can vary and still be assumed to conform to the whole-set is the "conformal limit." Conformal limits for the purposes here have been arbitrarily set so that 33 percent of the sample falls within the conformal limits of the adjusted means.

Figure 2 is a graphical representation of some of the data in Table 8. The abscissas on the figure give the adjusted mean of the semester credits required in various curricular areas of engineering technology programs. The bold line is a "profile" of such requirements; the shaded area represents the conformal limits of this profile.

FIGURE 2.--Profile of the Curriculum Structure of a "Typical" Engineering Technology Program, Showing Conformal Limits of the Sample Investigated.



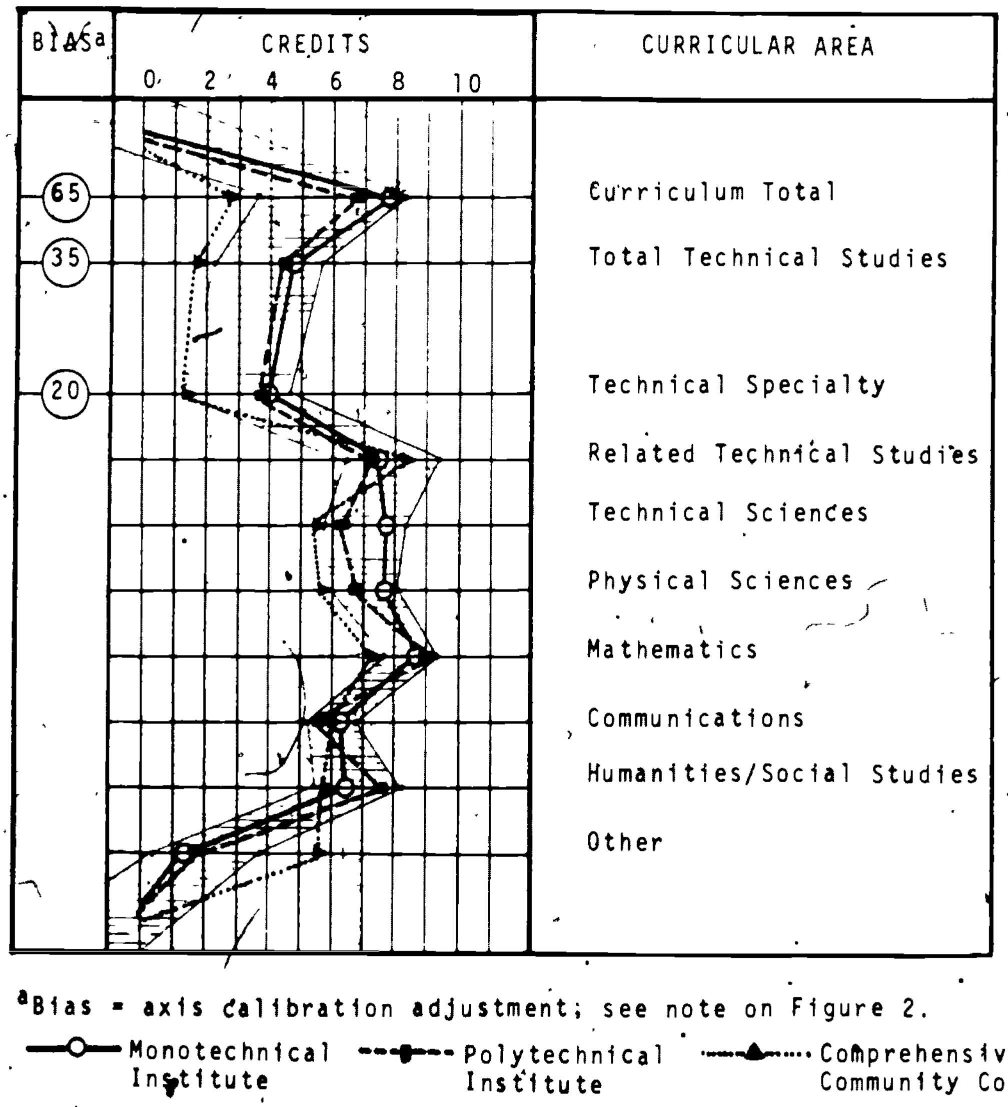
[a]Bias = axis calibration adjustment; e.g., for "Curriculum Total", read 65 + 6 = 71 credits.

Curricular Differences
Related to Institutional Setting

It was initially assumed that the curriculum structure of an engineering technology curriculum might vary with the institutional setting in which the curriculum is offered. To test this hypothesis, the profiles of three subsets of curricula--those existing in monotechnical institutes, polytechnical institutes, and comprehensive community colleges-- were plotted and compared to the whole-set profile. The results are shown in Figure 3. Table 9 gives the corresponding numerical data. The shaded area on Figure 3 represents the conformal limits of the whole-set profile (see Figure 2 and the accompanying discussion).

As can be readily seen from Figure 3, the profiles of the curricula which are offered in monotechnical institutes and in polytechnical institutes correspond closely and fall everywhere

FIGURE 3.--Profiles of Curriculum Structure of Engineering Technology Programs in Monotechnical Institutes, Polytechnical Institutes, and Comprehensive Community Colleges



[a]Bias = axis calibration adjustment; see note on Figure 2.

TABLE 9.--Mean Requirements by Curricula Area of Associate Degree Engineering Technology Programs Offered in Various Institutional Settings, as Calculated from a Sample of 120 Such Curricula.

Curricular Area	Monotechnical Institutes	Polytechnical Institutes	Comprehensive Comm. Colgs
Technical Specialties	24.0	23.9	21.2
Related Technical Studies	7.5	7.4	8.3
Applied Sciences	7.7	6.2	5.5
Physical Sciences	7.7	6.8	5.6
Mathematics	8.8	9.0	7.2
Communications	6.3	5.6	6.0
Humanities/Social Studies	6.4	7.7	5.8
Other	1.4	1.6	5.6
Total Technical Studies	39.9	39.7	36.7
Curriculum Total	72.8	71.8	67.7

within the conformal limits of the whole-set profile. Programs in comprehensive community colleges, however, appear to have a curriculum structure with a somewhat different profile. The differences are discussed in the following:

1. Community College curricula are shorter. This is not unexpected. Community colleges feel somewhat constrained to maintain equivalency in the length of all programs they offer; thus, the traditional length of the transfer (liberal arts) curriculum, 60-64 semester hours, provides a boundary condition for the total length of curricula in technical fields.

2. Community college curricula have lower requirements for total technical studies. This is an obvious corollary of the previous finding. What is surprising, however, is that the distribution of "total technical studies" in community colleges is irregular with respect to the whole-set profile rather than being uniformly lower. For example, the amount of technical specialty subject matter required, although less than the mean, is within the conformal limits of the whole-set, but related technical studies appear to a greater extent than the mean and technical sciences are below the conformal limits.

3. Physical science and mathematics appear as requirements in community-college-based engineering technology curricula to a lesser extent than these subjects do in curricula from other institutional settings.

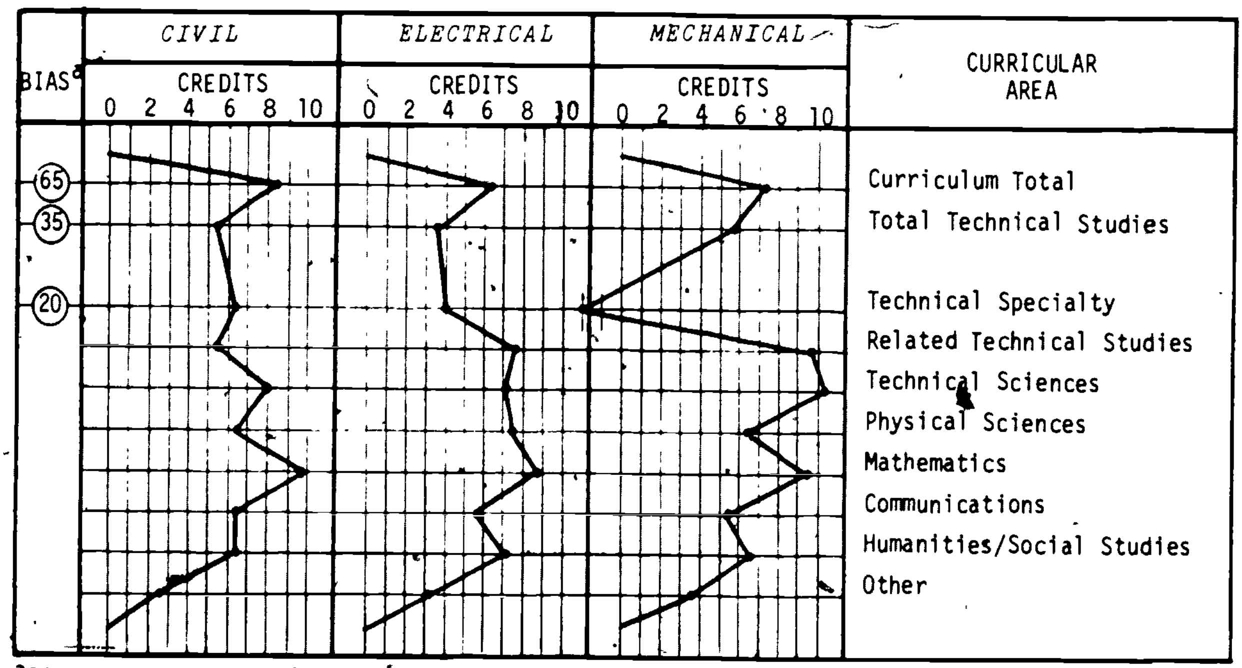
4. An appreciably greater number of credits in the engineering technology curricula having a community college setting are in the "other" category, that is, are comprised of physical education, R.O.T.C., foreign language, and "free" electives.

The differences just noted are individually minor, but considered collectively lead to the inferences that community college curricula in engineering technology tend to be (1) less broadly based, since they tend to have fewer credits in the applied and physical sciences areas, and (2) less abstract, since they tend to have a somewhat more limited mathematics content. And because their subset profile differs from that of the sample as a whole, it is also possible to infer that the curriculum structure of community college engineering technology programs may be based on an educational philosophy different from that which motivates monotechnical and polytechnical institutes. *Such a generalization, however, is tenuous and must be used with extreme caution.*

Curricular Differences Related to Technical Discipline

Engineering technology curricula were expected to show some differences related to the technical disciplines of the programs. For example, it was assumed that the typical curriculum structure of an electrical technology program might differ from that of a civil technology program. To test this hypothesis, the curriculum structure profiles of three subsets of curricula--*mechanical, civil, and electrical*--were plotted and compared. These were curricula all in the same kind of institutional setting; namely, polytechnical institutes. Figure 4 shows the results. As can be observed from

FIGURE 4.--Structural Profiles for Three Kinds of Associate Degree Engineering Technology Curricula, Illustrating Inter-program Structural Variance by Technical Discipline.



[a]Bias = axis calibration adjustment; see note on Figure 2.

the figure, programs in different technical disciplines sometimes differ appreciably in the way in which requirements are distributed, especially in the technical areas of the curricula.

Because the curriculum structures of programs in different technical disciplines do deviate from each other, an effort was made to assess this relative variance as compared to the variance in the structures of programs in different institutional settings. Hence, an analysis was made of the average difference in means [illegible]or each set of profiles. The set of means for the entire sample [illegible] the whole-set) was used as a reference. Absolute values [illegible]ferences between whole-set means and corresponding subset means were calculated point-by-point. Then, the averages of these point-by-point differences were calculated. The average difference of means was 0.81 semester credits for programs in different institutional settings and 1.15 semester credits for programs in different cognitive domains. Thus, for the programs in this sample, the profile variance attributable to the "major" or "specialty" of engineering technology curricula is approximately 45 percent higher than that attributable to institutional setting. *The structural variation between curricula appears to be more dependent on the kind of technology with which it deals than on the kind of institution offering it.* This may be an important finding.

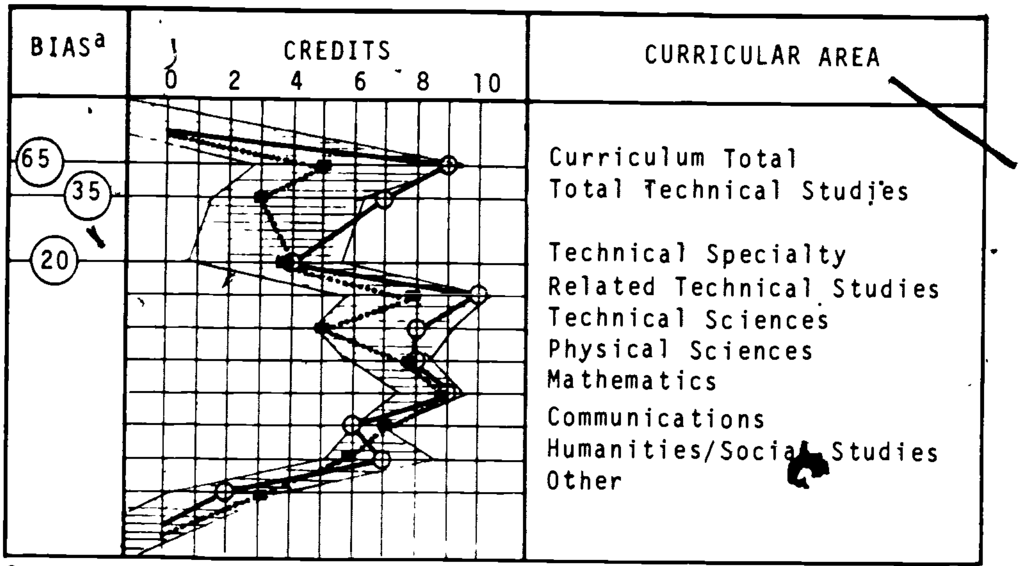
Curricula Differences
Related to Accreditation Status

An investigation was made of the differences which may exist between engineering technology programs accredited by the Engineers' Council for Professional Development and programs not so accredited. Two subsets of 25 members each were randomly selected from the total sample; one such subset consisted of accredited programs, the other, of nonaccredited programs. To test a hypothesis that differences exist, the structural profiles of accredited and non-accredited curricula were plotted. Figure 5 displays the results. The shaded area on the figure represents the conformal limits of the sample.[1] With one minor exception (total technical studies for accredited curricula), both profiles fall within the conformal limits of the whole sample's structural pattern. The hypothesis of difference is <u>not</u> sustained; the inference is that the accreditation status of a curriculum and its structural profile are not significantly related.

---

[1]The conformal limits for this figure are greater, by a factor of 1.4, than those employed for the previous analyses (Figures 2 and 3). Use of subsamples for this particular analysis introduces statistical sampling errors which increase the probable error in the computed means and hence increases the range through which one must assume "conformity" of the profiles.

FIGURE 5.--Structural Profiles of ECPD-accredited and Non-accredited Associate Degree Engineering Technology Curricula



[a]Bias = axis calibration adjustment; see note on Figure 2.

ECPD-accredited Programs

Non-accredited Programs

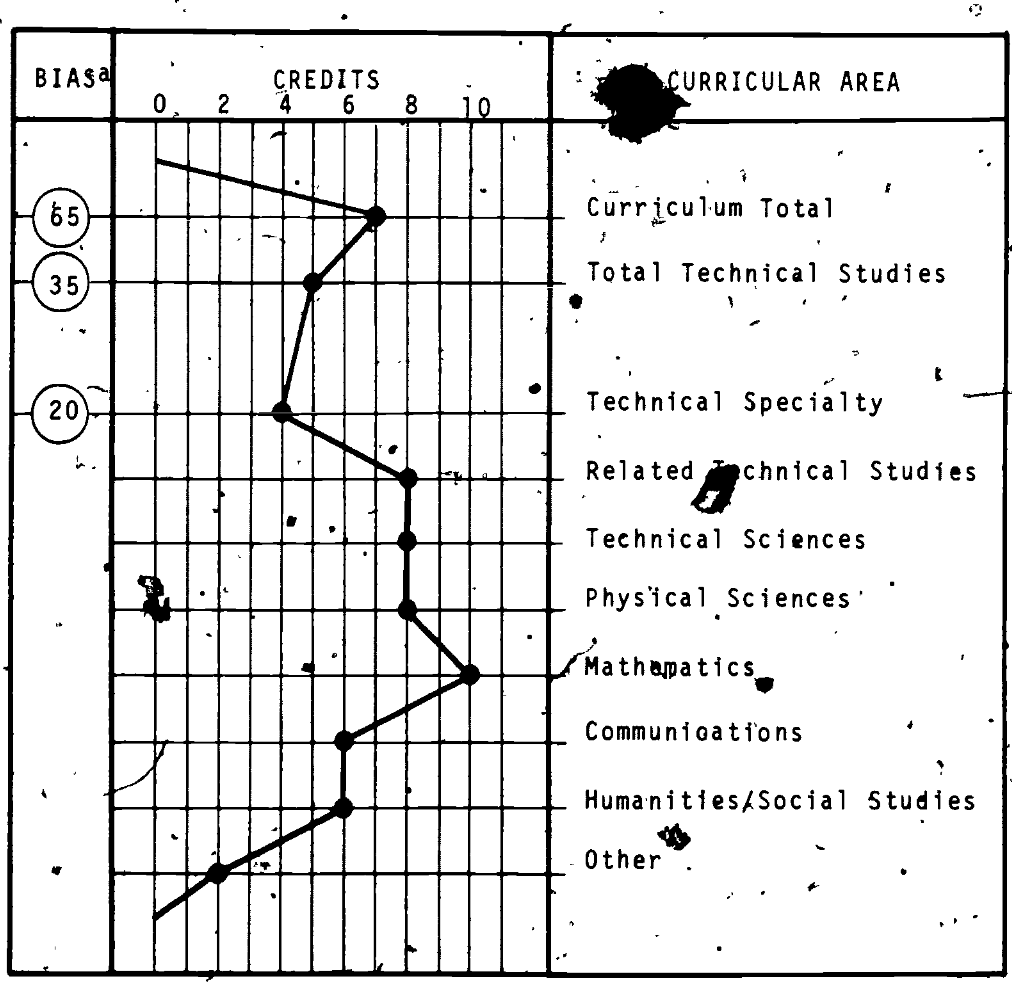
Modal Practices and
Inter-program Consistencies

As was pointed out earlier in this paper, some of the data related to curriculum structure in engineering technology programs have variability characteristics which tend to limit the value of the mean for interpretations of the central tendencies of the data. The mode in many cases is possibly a more useful statistic, especially in describing usual practice. For example, the "Humanities/Social Studies" component of curriculum structure (see Table 7) has associated with it a mean requirement of 7 semester credits; hardly any single program contains such a requirement Close examination reveals that the mode is 6 semester credits. In this case, actually three modes exist, one at 3 credits, another at 6 credits, a third at 8 credits; these presumably represent the practice of requiring either one 3-credit subject, two 3-credit subjects, or two 4-credit subjects in this area.

A profile of curriculum structure has been plotted to represent modal practice; this profile appears in Figure 6. In the figure, modes have been used as data points rather than the adjusted means which were employed for the previous plots. The general similarity of Figure 6 to Figure 2 (which was based on means) is noteworthy; Figure 6 has an advantage of easy interpretation in terms of the credit units conventionally assigned to college courses. Examination of individual curricula reveals that many engineering technology programs have structural profiles which trace major sections of the modal profile.

One possible explanation for inter-program consistency can be offered. ASEE's *Characteristics of Excellence* (the "McGraw Report") had, in 1962, suggested certain guidelines for the structure of engineering technology curricula. On Page 25 of this document, for example, an illustrative curriculum was presented, showing a recommended distribution of credits in certain curricular areas. That distribution is indicated in Table 10. Table 10 also gives for comparison purposes corresponding data for the curricular areas of the

FIGURE 6.--Modal Curriculum Structure Profile for Associate Degree Engineering Technology Curricula



[a]Bias = axis calibration adjustment; e.g., "Curriculum Total" = 65 + 7 = credits

TABLE 10.--Distribution of Credits in McGraw's "Illustration" and in the Modal Associate Degree Engineering Technology Program of 1970

Curricular Area	Semester Credits: Suggested by McGraw, 1962	Semester Credits: Modal Program, 1970
Total Technical Studies	39	40
Physical Sciences	6	8
Mathematics	12	10
Communications	6	6
Humanities/Social Studies	6	6
Other	3	2
Curriculum Total	72	72

modal engineering technology program discussed above. (Editorial revisions have been made both in the terminology used in the 1962 McGraw Report and that previously used here in order to facilitate comparison; the McGraw Report did not treat as many curricular subdivisions as were used here.) Examination reveals a high degree of correspondence between items in the table. The inference is that the 1962 McGraw Report has had a tremendous directive influence on the evolution of engineering technology education programs.

Summary

Engineering Technology Education programs are available in seven kinds of institutional settings:

1. Monotechnical institutes
2. Polytechnical institutes
3. Comprehensive Community colleges
4. Universities
5. Company schools
6. Service schools
7. Correspondence schools

The first four classifications account for the majority of the programs.

For various reasons, it is difficult to inventory the national effort in engineering technology education. Perhaps the best estimate of the population is that approximately 560 institutions offer nearly 1600 curricula.

Curriculum structure in engineering technology education programs varies somewhat with institutional setting and with the technical discipline of the programs. Analysis of the distribution of the number of semester credits required in various curricular areas leads to the following estimates of "typical" structural profiles:

Curricular Area	Mean Requirement
Technical Specialty	23
Related Technical Studies	8
Applied Sciences	7
Physical Sciences	7
Mathematics	8.5
Communications	6
Humanities/Social Studies	7
Other	2
Total Technical Studies	39
Curriculum Total	71

Profile analysis yeilds the following:

1. Monotechnical and polytechnical institutes offer programs with essentially identical structures.

2. Community colleges offer programs which are shorter in total length, contain fewer credits in physical science and mathematics, and have more "free" electives.

3. University-based programs are like those in monotechnical and polytechnical institutes.

4. Curriculum structure varies more with program emphasis (technical discipline) than with institutional setting.

5. Programs which are accredited by ECPD do not differ significantly in their curriculum structure from programs not ECPD accredited.

A comparison of the "modal" profile of existing engineering technology curricula (the mode being for this purpose a more useful descriptive statistic than the mean) with the illustrative curriculum in the McGraw Report reveals close correspondence between these two.

Implications

The possible implications of the analysis described in this paper must be extrapolated, for they are not entirely explicit in the data. The implications fall into two major domains.

First, it can be readily noted that the majority of engineering technology curricula have semester hour requirements--regardless of the institutional setting--which exceed those normally associated with two years of college work. The range of requirements of the associate degree in engineering technology was found to be from 60 to 83 semester credits, with a mean of 71 and a mode of 72. To many observers, such data indicates a serious "overcrowding" of the curriculum, especially when the mean abilities of entering students (see Chapter 7, herein) are considered. There may also be implications that only certain kinds of institutional settings are appropriate for engineering technology programs.

And secondly, the lack of variability among programs--in most of the curricular areas treated and with respect to several different variables--suggests that a "lock-step" configuration may exist in this educational domain. While inter-program conformity may well help assure that certain minimum standards are being widely met, a high degree of such conformity may indicate that little educational experimentation or innovation is occuring in the area. The characteristics of engineering technology curricula are well defined; all programs in this area have structural patterns which are surprisingly similar and the differences which do exist among programs are minor. But such conformity in itself gives rise to a dilemma with which educators and others sensitive to the needs in the area must wrestle.

CHAPTER 3

ILLUSTRATIVE CURRICULUM GUIDES FOR ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

CHAPTER 3

ILLUSTRATIVE CURRICULUM GUIDES FOR ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

The purpose of this chapter is to illustrate, without making evaluations, the kinds of curriculum guides which appear in the catalogs or bulletins of institutions which offer associate degree programs in engineering technology. Four examples are listed. In each case, a brief description of the institutional setting of the curriculum is given, but institutions are not otherwise identified; course numbers, for example, have been omitted. The objective is merely to illustrate contemporary practice, not to imply endorsement of the examples presented. These illustrations are not necessarily to be regarded as models.

An Electronics Engineering Technology Curriculum

This electronics engineering technology curriculum is offered by a large, public, comprehensive community college in the western part of the United States. The total college enrollment exceeds 10,000 students. Approximately 600 students are enrolled in associate degree engineering technology programs; one-fourth of these are in electronics engineering technology. The institution operates on a semester calendar. The institution is regionally accredited, and the electronics curriculum is accredited by ECPD.

Table 11 shows the curriculum guide; individual subjects descriptions, quoted or paraphrased from the institution's catalog, are given in the following:

Freshman English 1.--This course emphasizes writing adequate English prose and includes practice in English fundamentals and elementary semantics. Frequent practice in descriptive, narrative and expository writing stresses sound organization and technical correctness; collateral reading is also required.

Freshman English 2.--Writing and discussion are based on extensive and intensive reading and critical evaluation of literary material. Research is required, the emphasis being placed upon techniques of getting information, taking notes, constructing outlines, organizing material, and writing the documented report.

Mathematics for Electronics Technicians.--Including the basic principles of algebra and trigonometry, this course contains applications selected from the field of electronics.

TABLE 11.--An Electronics Engineering Technology Curriculum

FRESHMAN YEAR

First Semester

Subject	*Credit*[1]
Freshman English 1	3-0-3
Mathematics for Electronics Technicians	4-0-4
Introduction to Electronics	5-6-7
Drafting for Electronics Technicians	0-6-2
Physical Education[2]	0-2-1
	12-14-17

Second Semester

Subject	*Credit*
Freshman English 2	3-0-3
Circuit Analysis	3-0-3
Base Electronics	5-6-7
General Education Elective	3-0-3
Physical Education	0-2-1
	14-8-17

SOPHOMORE YEAR

Third Semester

Subject	*Credit*
Intermediate Electronics	3-3-4
Communications Electronics	3-3-4
Calculus for Electronics 1	3-0-3
General Physics 1	3-3-4
General Education Elective	2-0-2
Physical Education	0-2-1
	14-11-18

Fourth Semester

Subject	*Credit*
Pulse Circuits	3-3-4
Digital Computer Fundamentals	3-3-4
Calculus for Electronics 2	3-0-3
Electronics Measurements and Instrumentation	0-4-2
Physical Education	0-2-1
	12-15-18

[1]Entries under "Credit" are given as class periods per week, laboratory periods per week, and semester hours credit, respectively; thus, the entry 5-6-7 implies a subject which meets 5 hours per week in class, 6 hours per week in laboratory, and yeilds 7 semester hours credit.

[2]Physical Education is an institutional requirement; this curriculum contains 66 semester hours of academic work plus 4 semester hours of physical education for a total of 70 semester hours credit.

The work covers simultaneous equations, quadratic equations, and basic trigonometric relationships, with the emphasis placed on network problems and the solution of alternating current circuits.

Calculus for Electronics 1,2.--These are courses in the methods and results of calculus which are of the most direct use in the study of circuits. Study in the first course begins with the fundamental concepts and the basic operations of calculus as applied to power functions. The second course deals with trigonometric, logarithmic and hyperbolic functions, infinite series, and an introduction to differential equations.

Drafting for Electronics Technicians.--This is a one semester course designed to provide electronic technicians with basic skills in orthographic projection, dimensioning, chassis layout, block diagrams and circuit diagram layout.

General Physics 1,2.--General Physics includes the following fields: mechanics, properties of matter, wave motion, sound, heat, magnetism, electricity, light, and atomic structure. The main objectives of the course are to acquaint the student with the experimental method, to develop laboratory skills, and to build up an organized body of knowledge related to physical phenomena encountered in the student's life. Necessary trigonometry will be developed in the course; intermediate algebra is a prerequisite.

Introduction to Electronics.--Covering the electrical fundamentals of electronics, this course is intended for those students who have no previous knowledge of electronics. It includes Ohm's law, DC circuits, power, meters, magnetism, batteries, inductance, capacitance, resonance, AC circuits, filters. Laboratory includes basic shop practices and work with electronics test instruments.

Circuit Analysis.--This course provides an extensive coverage of electrical principles as applied to electronics circuits. Included are such topics as basic network analysis, Thevenin's theorem, magnetic circuits, inductance, capacitance, alternating current circuits, impedance matching, resonance, etc. Essentially, this is a problem course with the continuous application of theory to practical circuit analysis.

Basic Electronics.--Providing comprehensive coverage of the whole field of electronics, this course begins with a study of vacuum tube and transistor principles and parameters. This is followed by a detailed analysis of rectifier circuits, and audio and video amplifiers, and radio frequency amplifiers. The laboratory work is closely coordinated with the lectures in order to develop practical applications of the theoretical concepts.

Intermediate Electronics.--Primarily a study of transistor physics and circuits, including a study of transistor parameters and large signal and small signal amplifier design, this course covers transistor bias and stability methods and extensive qualitative analysis of many special semiconductor devices and circuits.

Communications Electronics.--Topics include AM, FM, mobile communications equipment, television transmitters and receivers, alignment and trouble-shooting techniques.

Pulse Circuits.--This course includes pulse amplifiers, linear wave-shaping, non-linear wave-shaping, multivibrators, timebase oscillators and generators, and applications of pulse circuits.

Digital Computer Fundamentals.--This course includes an introduction to the logic and circuitry of digital computers, a survey of computers and computer programming, number systems and binary arithmetic, and Boolean algebra as applied to logical design. Included also is study of the basic electronic circuits used in digital computers, computer arithmetic operations, memory elements, and input-output devices.

Electronics Measurements and Instrumentation.--A study of various electronic instruments and measurement techniques used in testing and analyzing electronic circuits. The course covers devices and methods used for sensing and presenting visual displays of various quantities, including transducers, oscilloscopes, analog and digital display devices, recorders, and telemetry.

A Civil Engineering Technology Curriculum

This civil engineering technology curriculum is offered at a public monotechnical institute which is a separate branch of a southeastern engineering college. The branch has approximately 1000 students enrolled in ten engineering technology curricula; about one-third of the enrollment is in civil engineering technology. A quarter-based calendar is used. The curriculum currently is accredited by ECPD, and the institution is accredited by the appropriate regional association.

Table 12 shows the curriculum guide; individual subjects in the curriculum are described in the following quotations or paraphrases from the institutional catalog:

English 1.--Planning the composition, effective paragraphs, effective sentences, some attention to grammar and punctuation.

English 2.--Vocabulary building, dictionary study, practice in developing sentence style, precise writing, paragraph technique, and business correspondence.

Technical Writing.--Study of the fundamentals of technical writing style and mechanics, with practice in preparing reports of the various types most likely to be used on the job by engineering technicians.

Public Speaking.--Study and practice in the fundamentals of public speaking. The subject includes training in selecting a topic, obtaining and organizing material, and presenting speeches effectively. Each student makes several speeches before an audience.

Psychology.--A study of basic psychological causes of human behavior which includes both environmental stimulation and internal factors such as needs, drives, attitudes, and frustration; followed by psychological testing and placement and group behavioral patterns applied to such areas as group communications and interactions, group leadership, industrial training, and industrial safety.

Engineering Drawing.--Introduction to drawing, use of instruments, lettering, geometric construction, orthographic projection, auxiliary views, dimensioning, and drawing conventions.

TABLE 12.--A Civil Engineering Technology Curriculum

FRESHMAN YEAR

First Quarter: Subject	Credit[1]	Second Quarter: Subject	Credit	Third Quarter: Subject	Credit
Materials and Architectural Drawings	5-0-5	Elementary Surveying 2	1-6-3	Highway Surveying and Construction	5-6-7
Elementary Surveying 1	1-3-2	English 1	3-0-3	Engineering Mechanics	2-0-2
Engineering Drawing 1	0-6-2	Trigonometry	5-0-5	English 2	3-0-3
Algebra	5-0-5	Physics 1	4-2-5	Analytic Geometry and Calculus	5-0-5
Computer Programming	0-3-1				
	11-12-15		13-8-16		15-6-17

SOPHOMORE YEAR

Fourth Quarter: Subject	Credit	Fifth Quarter: Subject	Credit	Sixth Quarter[2]: Subject	Credit
Strength of Materials	3-2-4	Municipal Sanitation and Hydraulics	4-3-5	Estimating	3-3-4
Land Surveys	2-6-4	Soils and Materials Testing	3-6-5	Structural Drafting, Concrete	0-4-2
Physics 2	4-2-5	Technical Writing	3-0-3	Topographic and Contour Surveying	2-6-4
Psychology	5-0-5	Physics 3	4-2-5	Heavy Construction	2-3-3
				Public Speaking	3-0-3
	14-10-18		14-11-18		10-16-16

[1]Entries under "Credit" indicate, respectively, class hours, laboratory hours, quarter credit hours.

[2]The curriculum total is 100 quarter hours (approximately equivalent to 66 semester hours); no electives appear.

Algebra.--Systems of equations; exponents and radicals; quadratic functions; graphs of functions; ratio, proportion and variation; complex numbers; higher degree equations; inequalities; logarithms; progressions and determinants.

Trigonometry.--Trigonometric functions, plane right triangles, reduction formula, fundamental relations, identities, addition formulas, double angles, half angles, inverse functions, solution of oblique triangles, logarithms, and complex numbers.

Analytic Geometry and Calculus.--An introduction to the analytical study of the straight line and conic sections. A survey of fundamentals of the calculus, including the differentiation and integration of polynomials. Applications to rectilinear motion, macima and minima, areas, maxima, fluid pressure, and work.

Computer Programming 1.--An introduction to programming the digital computer for solving elementary problems in mathematics and technology.

Materials & Architectural Drawings.--An introductory study of reading architectural drawings, the physical properties of materials that are used in structures, and the language of construction.

Elementary Surveying 1.--Care and use of engineer's level, transit and tape, leveling, traversing.

Elementary Surveying 2.--Continuation of Surveying 1: Closure and area computations, stadia, contours, building layouts, profile levels, U.S. System of Land Surveys, earthwork, lines and grades, city surveys, the interpretation and plotting of field notes of topographic surveys.

Highway Surveying and Construction.--A study of highway location, geometric considerations, drainage and sizing of drainage structures, grading and earth movement, soil stabilization and road surfacings, and preliminary and construction surveys for route locations. Included are simple, compound, reverse, and multi-centered circular curves, highway and railway spiral easement curves, superelevations, and parabolic vertical curves. The laboratory time is used for field layout of curves, earthwork problems, and the preparation of a complete set of highway plans.

Municipal Sanitation and Hydraulics.--A study of sources, collection, treatment, and distribution of municipal water and sewage systems. The subject matter includes fluid statics, flow of an incompressible ideal fluid, flow of real fluid in pipes, multiple pipe-line problems, liquid flow in open channels and fluid measurements. The laboratory time is used for fluid-flow measurements and visits to water and sewage plants.

Structural Drafting-Concrete.--A study of various types of concrete floor systems and preparation of working drawings for the concrete members of a structure. As a term project, the student is given the design for a multi-story concrete framed building from which he prepares the structural plans and the shop details for a part of the reinforcing steel.

Engineering Mechanics.--Statics; principles and applications of free body diagrams for force systems, shear and moment diagrams, deflections of beams by numerical integration, determination of section properties.

Strength of Materials.--A discussion of strength of materials concepts. Subject matter includes stress and strain analysis, both elastic and plastic, with emphasis on elastic analysis of axially loaded members, connectors, beams and columns.

Estimating.--A course designed to develop a method of preparing material and labor quantity surveys from actual working drawings and specifications.

Soils & Materials Testing.--A study of aggregates, cement, concrete, soils. Testing aggregates, mix designs, adjustments, slump, calculations of concrete characteristics, actual mixing, curing and testing. Theory of soil mechanics as applied to permeability, consolidation, shear strength, unconfined and triaxial compression. Inplace density, Atterberg limits, compaction tests, specific gravity, grain size, classification of soils. Asphalt properties, mix design, and testing.

Land Surveys.--Theory and practice of land surveying, subdivision; filing and recording deeds; U.S. system of land subdivision; plane coordinate systems; county and state laws; city surveying procedure; use of instruments and computations on astronomical observations for azimuth determination; State Land Lot System of land subdivision.

Topographic and Contour Surveying.--Theory, description, and use of advanced surveying instruments and methods; practice of state and local coordinate systems for cadastral surveys and construction work; field work for the design and construction of engineering projects; use of the Plane Table on Topographic surveys; altimetry, optical-type instruments; triangulation; base-line measurements; hydrographic surveying.

Heavy Construction.--Heavy construction operations; fundamentals, equipment, earth excavation and movement, drilling and blasting, production of stone aggregate, concrete mixing and placing, pile driving, cofferdams, foundations.

Physics 1 (Mechanics).--An introduction to Newtonian mechanics. The subject matter includes measurement, accelerated motion, ballistics, the laws of motion, friction, statics, circular motion, work, energy, momentum, rotary motion, simple machines, elasticity, simple harmonic motion, and the statics and dynamics of fluids.

Two demonstration lectures and two recitations per week. Laboratory exercises supplement the work in the classroom.

Physics 2 (Electricity and Magnetism).--An introduction to electromagnetic theory and its simpler applications. The subject matter includes electrostatic forces, fields, and potentials, electric current, resistance, simple d-c circuits, capacitance, magnetic forces and fields, electromagnetic induction, inductance, simple a-c circuits, and electromagnetic radiation.

Two demonstration lectures and two recitations per week. Laboratory exercises supplement the work in the classroom.

Physics 3 (Heat, Sound, Light, Modern).--An introduction to the theories of heat, sound, and light and a study of their simpler applications. The subject matter includes thermometry, elementary thermodynamics, heat transfer, wave motion, sound, reflection and refraction of light, and physical optics.

The modern physics segment includes brief considerations of relativity, quanta, atomic structure, the nuclear the nuclear atom, radioactivity and nuclear energy.

Two demonstration lectures and two recitations per week. Laboratory exercises supplement the work in the classroom.

A Mechanical Engineering Technology Curriculum

This mechanical engineering technology curriculum is offered by a public polytechnical institute in the northeastern section of the United States. The institution has a total enrollment of approximately 450 students; some 350 of these are enrolled in five engineering technology programs offered, about 80 in this curriculum. The curriculum is accredited by ECPD. A semester-based calendar is employed.

Table 13 gives the curriculum guide; the subject descriptions, abstracted from the institution's catalog, appear in the following:

Technical Drafting 1.--This course provides basic knowledge of the standards and uses of drafting and develops skill in the use of drafting equipment. It covers lettering, principles of projection, auxiliary views, sketching, layout, geometric construction, and dimensioning.

Technical Drafting 2.--The fundamentals of graphic theory as applied to mechanical engineering problems as developed through a study of the relative position of points, lines, and planes in space; also covered are intersections and developments of geometrical solids, the recognition of standard symbols for materials and mechanical parts, and their use in diagrams and drawings.

English 1.--Designed to teach the student to read and think critically, to write effectively and to understand the fundamentals of written and oral composition. Sentence structure, paragraph development, and the construction of essays involving the collection and use of materials are stressed. Attention is given to the proper delivery of oral material. Some instruction is given in the principles of correspondence. A major research paper is required in this course.

English 2.--A continuation of English 1, stressing the analysis and development of the formal patterns of expository writing. Selected works from both classical and current literature are critically examined and evaluated in lecture as a basis for class discussion. Theme assignments range from the simpler types of expository writing to the formal research paper. A major written report is required.

Manufacturing Processes 1.--A study of the various manufacturing processes used in industry. Laboratory work includes layout work and the use of the basic hand tools, and the operation of drills, milling machines, shapers, and grinders. Demonstrations are given with automatic and special machines. Field trips are taken to local manufacturing plants.

Manufacturing Processes 2.--This course places emphasis on the hot manufacturing processes and includes the study of metallurgy, foundry work, and the fabrication of metals by welding. Laboratory work includes the preparation of metallurgical specimens for metallographic examination and to interpret grain structure. Work is given in heat treating and the use of the Brinell, Rockwell, and Scleroscope hardness testing machines.

Strength of Materials.--The first part of the course deals with statics, including various forces and static and kinetic friction, and a review of physics leading into a study of the physical properties of common materials. Study is made of the internal stress and deformation of elastic bodies resulting from the action of external forces.

Hydraulics & Pneumatic Control.--A study of elementary fluid mechanics with emphasis on the use of hydraulics and pneumatics for power transmission and for control purposes. A study of the basic components of hydraulic and pneumatic systems and how they are combined to build up various circuits.

TABLE 13.--A Mechanical Engineering Technology Curriculum.

FRESHMAN YEAR

First Semester Subject	Credit	Second Semester Subject	Credit
Manufacturing Processes 1	3-3-4	Manufacturing Processes 2	2-3-3
English 1	3-0-3	English 2	3-0-3
Technical Drafting 1	0-6-2	Technical Drafting 2	0-6-2
Technical Mathematics	5-0-5	Calculus	4-0-4
Physics 1	3-3-4	Computer Programming	2-0-2
Physical Education	0-2-0	Physics 2	3-3-4
		Physical Education	0-2-0
	14-14-18		14-14-18

SOPHOMORE YEAR

Third Semester Subject	Credit	Fourth Semester Subject	Credit
Strength of Materials	3-3-4	Machine Design	3-3-4
Hydraulics & Pneumatic Controls	3-3-4	Design Problems	2-6-4
Tools & Jig Design	2-6-4	Electricity & Control	3-3-4
Basic Mechanisms	2-6-4	Labor Economics	3-0-3
Principles of Economics	3-0-3	Introduction to Philosophy	3-0-3
	13-18-19		14-12-18

Electricity & Controls.--An introduction to electrical circuits and equipment with emphasis on the concepts of electrical physics. The lab portion and part of the classwork place special emphasis on electrical control circuits and how they are used in conjunction with hydraulics and pneumatic circuitry.

Basic Mechanisms.--A study of the characteristics of mechanisms used to provide motion. The uses and design of belts, linkages, cams, ratchets, valves, clutches, universal joints, and gears are a few of the problems considered.

Machine Design.--The design principles of machine elements and the calculations necessary in determining the size and shape of various machine parts. Attention is given to the various types of loading conditions, stresses, tolerances, finishes, and other factors which must be considered in the design of machine elements.

Tool and Jig Design.--This course applied the application of design principles, mathematics, and basic science to the study of the design of cutting tools, gages, and holding devices which may be required in the manufacture of items by automation and mass production.

Design Problems.--The opportunity to use advanced drafting techniques while designing a complete machine or component parts. The application of knowledge of mathematics and science to practical problems in designing. The course is designed to encourage the student to use his judgment, initiative and knowledge to complete a problem.

Technical Mathematics.--Relation of mathematics to engineering applications and development of an appreciation of the importance of precision in mathematical thought. Covers use of slide rule, solution of linear and quadratic equations, exponents and radicals, logarithms, exponential functions, sine and cosine laws, binomial expansion and progressions, vectors, operations with imaginary and complex numbers, polar and rectangular coordinates, trigonometric identities and equations, graphs of trigonometric functions, and selected topics from mathematics of investment.

Calculus.--Presentation of basic concepts of plane analytical geometry and calculus. Emphasis placed on techniques of differentiation and integration and their applications in the technical fields.

Computer Programming.--Introduction to flow charting and the BASIC and FORTRAN languages; their use in solution of mathematical and engineering problems; application of data to existing programs.

Physics 1.--The purpose of this course is to give the student in engineering technology a thorough study of the basic principles of physics. Topics covered in this course are systems of measurement; dynamics, including motion, acceleration, forces producing motion, and power; statics including concurrent and non-concurrent forces; heat including specific heat, latent heat, and heat transfer; fluids, including properties of gases, fluid pressure, density, buoyancy, and hydraulics; sound including simple harmonic motion, wave motion, and acoustics.

Physics 2.--This course in a continuation of Physics 1, and is a study of electricity and magnetism, including fields of force, potential, current, series and parallel circuits, energy, power, induction, capacitance, and AC series circuits; light, including reflection, refraction, thin lenses, spectra, interference, diffraction, and polarized light; atomic and nuclear physics.

Principles of Economics.--This is an introductory course in which theory and practice are integrated. It includes issues of public interest where economic analysis has a direct bearing. In the micro-economic area (dealing with the individual parts of the economy) price theory is covered; a heavy emphasis is placed on micro-economic theory in the area of unemployment, national income, inflation, the balance of payments, and economic growth. Economics is a systematic subject and its fundamentals are carefully studied.

Labor Economics.--This course deals primarily with such modern problems as unemployment, inflation, race relations and poverty. Union organization and its effects in the market structure are emphasized. Public and private approaches to security in old age, disability and unemployment are discussed in depth. Government legislation and control over the labor-management area are covered, especially the Wagner Act, The Taft-Hartley Act and the Landrum-Griffin Act; civil rights legislation, fair employment, equal pay legislation and labor negotiations are covered.

Introduction to Philosophy.--This course includes a methodical examination of the diverse viewpoints, methods, and conclusions of significant philosophers in such topics as political philosophy, ethics, philosophy of religion, theory of knowledge, and the problem of appearance and reality.

A Chemical Technology Curriculum

This chemical technology curriculum is offered by a public, comprehensive community college in the "Middle Atlantic" region of the United States. The institution originated as a polytechnical institute, but it has become comprehensive in its offerings fairly recently. The institution uses a quarter-based calendar. The institution is regionally accredited, ECPD has accredited this curriculum, and other specialized curricula have been accredited by the appropriate agencies. The college has more than 4000 students; 400 of these are in engineering technology programs, with about 30 in chemical technology.

The curriculum guide is given in Table 14; subject descriptions, quoted or paraphrased from the institution's catalog, appear in the following:

English 1.--Introduction to the nature and history of language. Semantics. Levels of usage. The construction of effective sentences and paragraphs. Critical reading of related essays.

English 2.--Instruction and practice in the different types of writing including informative, evaluative and persuasive. Style, tone and diction, and their relationship to the writer's purpose. Critical reading of related essays.

English 3.--The reading of prose selections dealing philosophically with man and his views of the world. Development of analytical reading, critical thinking and effective communication.

TABLE 14.--A Chemical Technology Curriculum.

FRESHMAN YEAR

First Quarter

Subject	*Credit*
Chemistry 1	4-3-5
Orientation	1-0-0
English 1	3-0-3
College Algebra and Trigonometry	4-0-4
Engineering Drawing	0-3-1
Physics 1	3-2-4
	14-8-17

Second Quarter

Subject	*Credit*
Chemistry 2	4-3-5
Sociology 1	3-0-3
English 2	3-0-3
Analytic Geometry and Calculus 1	3-0-3
Physics 2	3-2-4
	16-5-18

Third Quarter

Subject	*Credit*
Chemistry 3	4-6-6
Computer Programming	2-2-3
English 3	3-0-3
Analytic Geometry and Calculus 2	3-0-3
Physics 3	3-2-4
	15-10-19

SOPHOMORE YEAR

Fourth Quarter

Subject	*Credit*
Quantitative Analysis 1	3-6-5
Organic Chemistry 1	3-6-5
Stoichiometry	4-0-4
Analytic Geometry and Calculus 3	3-0-3
	13-12-17

Fifth Quarter

Subject	*Credit*
Quantitative Analysis 2	3-6-5
Organic Chemistry 2	3-6-5
Unit Operations 1	3-3-4
Sociology 2	3-0-3
	12-15-17

Sixth Quarter

Subject	*Credit*
Instrumental Methods of Analysis	3-6-5
Organic Chemistry 3	3-6-5
Unit Operations 2	3-6-5
Sociology 3	3-0-3
	12-18-18

Engineering Drawing.--A basic drafting course designed to orient the student in lettering, measurements, line work, use of instruments, sketching, orthographic projection. Exploratory work in the areas of dimensioning and notes, sections, auxiliaries and assemblies. Use of catalogs, printed data sheets.

Chemistry 1.--A theoretical treatment of fundamental principles and laws underlying chemical action, their integration with the theories of atomic structure and chemical bonding, and correlation with the position of the elements on the periodic chart. Atomic structure, the periodic chart, chemical bonding, the states of matter, gases, thermochemistry, chemical arithmetic, with emphasis on structure and energy changes.

Chemistry 2.--A continuation of Chemistry 1 to include solid and liquid structure, solutions, chemical and physical equilibrium, introduction to chemical kinetics, voltaic cells, electrolytic cells, redox, nuclear chemistry.

Chemistry 3.--First in a sequence of courses to familiarize the student with analytical chemistry in which both qualitative analysis and quantitative analysis are integrated. Theory in solution equilibria and chemical methods of separation and measurement. The laboratory work in qualitative chemistry includes the identification of the more important cations and anions and the analysis of mixtures. The quantitative portion includes gravimetry, neutralimetry, precipitimetry, redoximetry and compleximetry.

Quantitative Analysis 1.--A continuation of Chemistry 3 with an emphasis on the application of physical and chemical theory to the more important gravimetric, volumetric and elementary instrumental methods of analysis. Laboratory work requires statistical treatment of analytical data and the practical application of computer programming for quantitative analysis.

Quantitative Analysis 2.--Instrumental methods of analytical chemistry, primarily electrochemical methods. Laboratory experiments in potentiometry, polarography, coulometry, conductimetry, radiochemistry and electrogravimetry. Related technical report writing.

Instrumental Methods of Analysis.--Instrumental methods of analytical chemistry, primarily optical methods. Laboratory work in visible, ultraviolet and infrared spectrophotometry, chromatography--column, paper, thin layer, and gas. Chemical microscopy and emission spectroscopy.

Organic Chemistry 1.--Basic principles of organic chemistry, employing the reaction mechanisms and transition state considerations. Structure and reactivity, alkanes, free radicals, alkenes, carbonium ion theory, electrophilic addition, alkynes, dienes, resonance, elecrophilic aromatic substitutions, arenes, and alkyl halides; laboratory stresses basic techniques of reactions, separations and isolations.

Organic Chemistry 2.--A continuation of the study of additional classes of organic compounds followed by a study of tautomerism, stereochemistry, carbohydrates, proteins and dyes in terms of modern structural theory. Properties are linked to structure by a study of reaction rates, equilibrium, transition state and activation energy, reaction mechanisms, resonance and orbital theories.

Organic Chemistry 3.--The identification of organic compounds by correlation of fundamental properties and the behavior of organic compounds with their structures. Preparation and properties of polymers.

Stoichiometry.--A first course in chemical engineering background. Application of chemistry, physics and mathematics in solving engineering problems. Special emphasis on dealing with material and energy balances and the solution of problems.

Unit Operations 1.--A theoretical treatment of the basic unit operations of chemical engineering, including fluid flow, heat transfer, evaporation. Laboratory experimentation is conducted in the above areas using pilot plant size equipment.

Unit Operations 2.--A theoretical treatment of the basic unit operations of chemical engineering, including evaporation, distillation, drying, gas absorption and filtration. Laboratory experimentation is conducted in the above areas using pilot plant size equipment.

Algebra and Trigonometry.--Topics in algebra and trigonometry necessary in technical courses: system of real numbers, functions in general, graphs of functions, complex numbers, theory of equations, systems of equations, permutations and combinations, binomial theorem, as well as exponential, logarithmic and trigonometric functions.

Analytic Geometry and Calculus 1.--Rectangular coordinates in a plane, the straight line, slope and inclination equations of curves, discussion of a curve, functions and limits, indeterminate forms, continuity, the derivative, differentiation of algebraic functions.

Analytic Geometry and Calculus 2.--Applications of derivatives, maxima and minima, differentials, indefinite integral, definite integral, applications of definite integral. Area between curves, volumes by cylindrical washers and shells, length of plane curve, centroid and second moment of area, moment of inertia.

Analytic Geometry and Calculus 3.--Integration by standard forms, integration by parts, trigonometric substitution, partial fractions, use of table of integrals, applications of definite integrals. Trapezoidal and parabolic approximation, improper integrals, indeterminate forms, infinite series, expansion of functions in series.

Physics 1 (Mechanics).--Composition and resolution of vectors, equilibrium, concurrent and nonconcurrent forces, friction, statics, kinematics and linear motion, projectile motion, curvilinear motion, work and energy.

Physics 2 (Mechanics, Heat and Sound).--Power, impulse and momentum, oscillatory motion, fluid mechanics, thermometry, thermal expansion, thermodynamics, change of phase, heat transfer. Wave motion, intensity and quality of sound waves.

Physics 3 (Electricity and Magnetism; Light).--Coulomb's Law, electric fields, potential energy and potential, DC and AC circuits, conduction in solid liquids and gases. Photometry, geometrical optics, refraction and reflection, nature of light.

Sociology 1.--Sociological facts and principles dealing with the scientific study of human relationships. Emphasis on analysis and study of culture and human society, socialization, groups and group structure.

Sociology 2.--Stratification, collective behavior patterns and the various social institutions including associations, the family, and education. The application of sociological principles relating to the agents of social change.

Sociology 3.--The structure of the aggregates of population, minority groupings, crime and delinquency, and major changes in technology, urbanism and political structures as they relate to man.

CHAPTER 4

MATHEMATICS AND PHYSICAL SCIENCE IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY CURRICULA: A STUDY OF TOPIC COVERAGE IN SELECTED COURSES

CHAPTER 4

MATHEMATICS AND PHYSICAL SCIENCE IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY CURRICULA: A STUDY OF TOPIC COVERAGE IN SELECTED COURSES

This paper describes some characteristics of the mathematics, chemistry, and physics courses taught in institutions which offer associate degree engineering technology curricula. It gives some insights into the topics included in syllabuses for such courses and the relative emphasis placed on each topic by certain institutions chosen as illustrative examples. Where possible, inferences are drawn about factors which may be related to various differences discovered in topic coverage practice.

Procedures and Sample

Data for this study were collected by several means: personal visits by the writer to 24 institutions which offer associate degree engineering technology curricula; concommitant interviews with faculty members at these institutions; examination of catalogs and other institutional publications; and a series of questionnaires completed by faculty members teaching the courses which were the subjects of this investigation. The visits, interviews and document examination provided general information about the nature of these courses, the facilities provided for them, and the institutional philosophies related to them. The questionnaires sought to elicit information about the relative emphasis given to various topics in the syllabus for each course.

The 24 institutions which constituted the sample were selected from all geographic regions of the country and were equally representative of monotechnical institutes (institutions offering engineering technology curricula only), polytechnical institutes (institutions offering a variety of technical programs, health-business-, and other-related, as well as engineering technology), and comprehensive community colleges (institutions offering transfer, technical and adult education programs). The sample contained both institutions with one or more curricula accredited by ECPD and institutions with curricula not so accredited.

All institutions in the sample supplied catalog and document data; not all, however, responded to the questionnaires. In addition, some questionnaires were incomplete or late and were not included in the analysis. Furthermore, not all institutions offered a chemistry course, which further reduced the data base in that area. The limited data base, however, is not considered a serious defect, since the purpose of this study is to illustrate--rather than to define--practices in the presentation of mathematics and physical science in engineering technology curricula.

The investigation was limited to mathematics, chemistry, and physics subjects; the questionnaires related to each of these area are reproduced in Appendices B, C, and D, respectively. Faculty members indicated, in completing the questionnaires, the extent of topic coverage for various topics on a five-point scale, as follows:

A. Not Covered
B. Introduced Only
C. Brief Discussion
D. Covered in Some Depth
E. Covered in Detail

The choice of a subjective measure of topic coverage was deliberately made. Alternative techniques, which might have involved "time in class," "percent of total course," or similar pseudo-quantitative measurements, were deemed to be cumbersome and impractical in light of the resources available for subsequent analysis and the limited goals of the investigation.

Findings are reported separately for mathematics, chemistry, and physics. Details are given in tables appearing later in the report. In these tables, entries under the heading, *Frequency of Response, Coverage Given* represent the numbers of times which A, B, C, D, and E, respectively, were checked by the faculty members who responded to the questionnaire. Numbers in columns headed *Item Score* are obtained by first multiplying each frequency by an appropriate weighting factor (arbitrarily chosen here as 0 for A, 1 for B, 2 for C, 3 for D, and 4 for E), then summing these products, and finally dividing this sum by the total of the frequencies. That is,

$$S = \frac{\sum f_i w_i}{N}, \quad i = A, B, \ldots, E$$

where S=the item score, f_i=a given frequency, w_i=the weighting factor, and $N=\sum f_i$=the total frequency. The item score, S, thus represents a crude measure of the average relative emphasis given to each topic.

The value of S for a particular topic could conceivably range from 0 (no institution includes the topic) to 4.0 (all institutions cover the topic in detail); actual S values are expected to range less widely. It was judged sufficiently descriptive here to regard topics with an item score of 1.3 or lower as ones generally receiving little or no emphasis, topics with scores in the range from 1.4 through 2.7 as receiving "moderate" emphasis, and topics with item scores of 2.8 and above as receiving "substantial" emphasis. The *Relative Emphasis* columns in the data tables indicate the topics which appear to receive moderate (*) and substantial (**) emphasis in associate degree engineering technology programs.

Finally, the data tables will indicate--in instances where approciable differences appear to exist--whether technical colleges (T) or comprehensive community colleges (C) give the greater relative emphasis to a particular topic. Entries are made under a column headed *Emphasis Difference*. To obtain data for this column, item scores were separately computed for the technical colleges and the community colleges in the sample. These scores were compared and if they differed by more than 1.0, the appropriate symbol, T or C, was entered in the table to indicate which item score was greater.

MATHEMATICS

All associate degree engineering technology curricula contain courses in mathematics. An effort has been made here to identify the general characteristics of such courses by studying a small sample. The results of the study are presented in the following sections.

Nature of the Sample

The mathematics courses at 17 institutions were included in the analysis. Three other institutions submitted questionnaires, but these responses were late or incomplete and had to be rejected. The 17 institutions submitting usable data had a national distribution geographically and consisted of 9 technical colleges (monotechnical institutes and polytechnical institutes as defined elsewhere) and 8 comprehensive community colleges; 11 of these institutions had one or more curricula accredited by the Engineers' Council for Professional Development and 6 did not. The sample is reasonably representative by region and institutional type, but is slightly biased in favor of institutions with ECPD-accredited curricula.

General Observations

Most often, the mathematics sequence at the institutions in the sample appeared as a series of three courses each carrying 3 semester credits (5 quarter credits for institutions on a quarter-based calendar). Some variations in this pattern were discovered, including sequences such as 3-3, 4-4-4, 5-5-2, 4-3-3, and others. In general, the course titles associated with sequences of three courses were *Algebra, Trigonometry,* and *Elements of Calculus,* or similar titles; as might be expected, considerable variation among institutions was noted. The catalog descriptions of these courses frequently implied that the courses in the sequence--especially *Elements of Calculus*--were open to engineering technology students only. The catalogs also frequently implied that certain mimimum prerequisites had to be met for enrollment into the first course in the sequence; in most cases, remedial courses were offered, without credit, for the benefit of students who lacked such prerequisites.

Topic Coverage

The questionnaire related to topic coverage in mathematics (Appendix B) contained 466 items in 56 concept areas. Table 15 gives data on the relative emphasis given to these topics, as reported by the respondents.

It can be noted from the table that many topics were perceived to receive only limited treatment, if any. Topic coverage practices did not vary appreciably between technical colleges and comprehensive community colleges; significant differences in item scores (see definition *supra*) were detected for only 23 items out of the 466, a mere 5 percent. Where community college responses gave item scores which exceeded those of the technical colleges (10 cases), the items were in general related to fundamental theoretical concepts; where technical colleges had the larger item scores (13 cases), the items almost always were related to special applications of certain concepts.

Comments

It is interesting to examine the relative emphasis reported as given to each of the 56 major concept areas included in the questionnaire. Table 16 lists relative emphasis by concept area and by course with which the concept is usually associated. The table was constructed by noting the frequency with which items receiving moderate or substantial emphasis appeared in each concept area and evaluating the concept area appropriately. This table effectively summarizes the course syllabuses of mathematics courses currently being taught. It could serve (1) as a crude model for the development of courses by institutions considering inauguration of engineering technology curricula and (2) as a criterion against which

TABLE 15.--Coverage Given to Selected Topics in the Mathematics Course Sequence Intended for Students in Associate Degree Engineering Programs.

Item No	Topic, by Concept Area	Frequency of Responses, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
	1 The Number Systems of Algebra								
1	Sets	9	1	5	1	1	1.1		
2	The natural numbers	5	2	6	2	2	1.6	*	C
3	The real-number system	4	1	6	2	4	2.1	*	C
	2 The Fundamental Operations								
4	The relation of equality	1	1	2	7	6	2.9	**	C
5	Addition of monomials and polynomials	2	0	3	4	8	2.9	**	
6	Subtraction of monomials and polynomials	2	0	3	4	8	2.9	**	
7	Axioms and theorems of multiplication	2	1	4	3	7	2.7	*	
8	Law of signs for multiplication	2	0	5	2	8	2.8	**	
9	Law of exponents in multiplication	3	0	2	3	9	2.9	**	
10	Multiplication of two or more expressions	2	0	2	4	9	3.1	**	
11	Division of algebraic expressions	2	0	3	3	9	3.0	**	
	3 Special Products and Factoring								
12	The product of two binomials	1	0	2	3	11	3.4	**	
13	The product of two trinomials	3	1	3	5	5	3.1	**	
14	The square of a polynomial	2	0	3	5	7	2.9	**	
15	Factoring	1	0	2	2	12	3.4	**	
16	Factors of a quadratic trinomial	2	2	2	2	9	2.8	**	
17	Trinomials that are perfect squares	2	0	3	2	10	3.1	**	
18	Factors of a binomial	2	0	2	2	11	3.2	**	
19	Common factors	1	0	3	1	12	3.4	**	
20	Factoring by grouping	1	0	3	6	7	3.1	**	
21	Difference of two squares	2	0	3	2	10	3.1	**	
	4 Fractions								
22	Conversion of fractions	1	0	3	2	11	3.3	**	
23	Multiplication of fractions	1	0	3	1	12	3.4	**	
24	Division of fractions	1	0	3	1	12	3.4	**	
25	The lowest common denominator	2	1	2	2	10	3.0	**	
26	Addition of fractions	1	1	2	2	11	3.2	**	
27	Complex fractions	1	1	2	[illegible]	7	3.1	**	
	5 Exponents and Radicals								
28	Nonnegative integral exponents	0	0	1	4	12	3.6	**	
29	Negative integral exponents	0	0	1	5	11	3.5	**	
30	Roots of numbers	0	0	1	3	13	3.6	**	
31	Rational exponents	0	0	1	4	12	3.5	**	
32	Conversion of exponential expressions	1	0	1	4	11	3.4	**	
33	The product and quotient of two radicals	0	0	2	2	13	3.6	**	
34	Rationalizing monomial denominators	1	0	1	4	11	3.6	**	
35	Changing the order of a radical	0	0	3	5	9	3.4	**	
36	Addition of radicals	0	0	2	5	10	3.5	**	
37	Additional operations involving radicals	1	0	4	5	7	3.0	**	
	6 Linear and Fractional Equations								
38	Equivalent equations	0	0	3	5	9	3.4	**	
39	Linear equations in one unknown	0	0	0	6	11	3.6	**	
40	Fractional equations	0	0	0	4	13	3.8	**	
41	Solving stated problems	0	0	0	6	11	3.6	**	
	7 Quadratic Equations								
42	Solution by factoring	0	0	0	6	11	3.6		
43	Solution by completing the square	0	0	1	5	11	3.6		
44	Complex numbers	0	1	4	5	7	3.0	**	
45	The quadratic formula	0	0	1	3	13	3.7	**	
46	Equations in quadratic form	0	0	1	4	12	3.6	**	
47	Equations that involve radicals of the second order	0	0	2	6	9	3.4	**	
48	Problems that lead to quadratic equations	0	0	2	7	8	3.4	**	
49	Nature of the roots	1	1	5	8	2	2.5	*	
50	The sum and product of the roots	2	2	7	6	0	2.0	*	
51	Factors of a quadratic trinomial	1	3	1	7	5	2.7	*	
	8 Functions and Graphs								
52	Ordered pairs of numbers	3	0	2	7	4	2.4	*	
53	Functions	1	0	3	8	5	2.4	*	
54	Functional notation	1	0	3	8	5	2.4	*	
55	Relations	3	1	3	5	4	2.4	*	
56	The rectangular coordinate system	0	0	0	4	13	3.8	*	
57	The graph of a function	0	0	0	7	10	3.6	**	
58	The inverse of a function	1	3	2	7	4	2.5	*	

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	9 Systems of Equations								
59	Equations in two variables	0	0	2	5	10	3 5	**	
60	Graphs of equations in two variables	1	1	0	6	9	3 2	**	
61	Graph of a quadratic equation in two variables	2	0	0	8	7	3 1	**	
62	Graph of a linear equation in two variables	1	1	0	3	12	3 4	**	
63	Graphical solution of a system of equations	2	1	0	4	10	3 2	**	
64	Consistent, inconsistent, and dependent equations	3	0	4	6	4	2 5	*	
65	Algebraic methods of solution, system of equation	1	1	0	4	11	3 4	**	
66	Elimination by addition or subtraction	1	0	1	6	9	3 3	**	
67	Elimination by substitution	1	0	1	6	9	3 3	**	
68	Elimination by a combination of addition or subtraction and substitution	[illegible]	0	1	6	9	3 3	**	
69	Symmetric equations	5	2	4	6	0	1 6	*	
70	Problems leading to systems of equations	2	0	2	7	6	2 9	**	
71	Problems solvable by means of simultaneous quadratics	1	0	4	9	3	2 8	**	
	10 Elementary Determinants with Applications								
72	Determinants of the second order	0	2	2	6	7	3 1	**	
73	Solution of a system of two linear equations	0	1	4	4	8	3 1	**	
74	Systems of three linear equations	1	1	4	5	6	2 8	**	
75	Determinants of the third order	1	2	3	5	6	2 8	**	
76	Solution of a system of three linear equations	1	1	4	6	5	2 8	**	
	11 Complex Numbers								
77	Definitions	3	1	1	4	7	2 5	*	
78	Fundamental operations on complex numbers	3	1	1	3	8	2 6	*	
79	Geometrical representation	5	1	0	4	7	2 4	*	
80	Geometric addition and subtraction	5	1	0	3	8	2 5	*	
81	Polar representation	3	3	0	3	7	2.4	*	
82	The product of two complex numbers in polar form	4	2	1	3	7	2 4	*	
83	The quotient of two complex numbers in polar form	4	2	1	3	7	2 4	*	
84	De Moivre's theorem	7	1	0	4	5	1 9	*	
85	Roots of complex numbers	6	0	0	5	6	2 3	*	
	12 Higher-Degree Equations								
86	Rational-integral equations	5	0	5	5	2	1 9	*	
87	The remainder theorem	5	0	5	4	3	2 0	*	
88	Factor theorem and its converse	4	0	4	5	4	2 3	*	
89	Synthetic division	3	2	2	6	4	2 4	*	
90	Graph of a polynomial	3	0	2	7	5	2 6	*	
91	Locating the roots	4	1	2	6	5	2 5	*	
92	Number of Roots	3	1	2	8	3	2 4	*	
93	Bounds of the real roots	8	1	3	4	1	1 4	*	
94	Rational roots of a polynomial equation	6	1	1	7	2	1 9	*	
95	The depressed equation	8	3	1	3	2	1 3		
96	Process of obtaining all rational roots	6	2	3	5	2	1 8	*	
97	Descartes's rule of signs	9	0	6	1	1	1 1		
98	Imaginary roots	3	3	2	7	1	1 9	*	
99	Irrational roots by successive magnification	11	2	2	2	0	7		
100	Transformation of an equation to decrease its roots	11	2	2	2	0	7		
101	Horner's method for determining irrational roots	14	2	0	1	0	3		
102	Identical polynomials	13	1	1	2	0	5		
103	The cubic equation	10	0	4	2	1	1 1		
104	The quartic equation	11	0	3	3	0	9		
	13 Inequalities								
105	Definitions, fundamental axioms, and theorems	4	1	4	4	4	2 2	*	
106	Conditional inequalities	4	2	4	2	5	2 1	*	
	14 Ratio, Proportion, and Variation								
107	Ratio	3	1	1	6	6	2 6	*	C
108	Proportion	3	1	1	6	6	2 6	*	C
109	Variation	4	0	0	6	7	2 7	*	C
	15 Logarithms								
110	Definitions	2	0	0	5	10	3 2	**	
111	Properties of logarithms	2	0	0	7	8	3 1	**	
112	Approximations	4	0	3	6	4	2 4	*	T
113	Scientific notation	3	0	0	6	8	2 9	**	C
114	Common, or Briggs, Logarithms	2	0	0	6	9	3 2	**	
115	Characteristic and mantissa	2	0	0	4	11	3 3	**	
116	Use of tables to obtain the mantissa	2	0	0	6	9	3 2	**	
117	Use of tables to find N when log N is given	2	0	0	6	9	3 2	**	
118	Logarithmic computation	2	0	0	10	5	2 8	**	
119	Logarithms to bases other than 10	3	0	4	7	3	2 4	*	C
120	Exponential and logarithmic equations	3	0	1	6	6	2 9	**	
121	The graphs of $\log_a x$ and of a^x	2	1	2	6	6	2 8	**	

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	16 *Progressions*								
122	Definition of progressions	5	3	2	4	3	18	*	
123	Arithmetic progressions	5	3	2	4	3	18	*	
124	Last term of an arithmetic progression	5	3	2	3	4	19	*	
125	Sum of an arithmetic progression	5	3	2	3	4	19	*	
126	Simultaneous use of the formulas for l and s	6	2	2	4	3	18	*	
127	Arithmetic means	6	1	4	3	3	18	*	
128	Geometric progressions	5	1	3	5	3	26	*	
129	Last term of a geometric progression	5	1	3	4	4	21	*	
130	Sum of a geometric progression	5	2	2	4	4	20	*	
131	Simultaneous use of the formulas for l and s	5	3	2	4	3	18	*	
132	Geometric means	9	4	3	3	1	14	*	
133	Infinite geometric progressions	7	1	4	1	4	17	*	
134	Harmonic progressions	9	0	5	3	0	11		
	17 *Mathematical Induction*								
135	Method of mathematical induction	11	2	2	1	1	8		
	18 *The Binomial Theorem*								
136	The binomial formula	3	3	3	4	3	19	*	
137	The rth term of the binomial formula	6	3	4	2	2	15	*	
138	Proof of the binomial formula	10	2	2	1	2	9		
139	Binomial theorem for fractional and negative exponents	8	2	4	1	2	12		
	19 *Permutations and Combinations*								
140	Definitions	12	0	3	2	0	7		
141	The fundamental principle	12	0	3	2	0	7		
142	Permutations of n different elements taken r at a time	12	0	3	2	0	7		
143	Permutations of n elements not all different	12	1	2	2	0	[illegible]		
144	Cyclic permutations	14	2	1	0	0	2		
145	Combinations	12	1	2	1	1	7		
146	The sum of certain combinations	12	1	2	1	1	[illegible]		
	20 *Probability*								
147	Mathematical probability	10	1	4	0	2	10		
148	Empirical probability	10	1	4	0	2	10		
149	Mathematical expectation	11	1	3	0	2	9		
150	Mutually exclusive events	11	1	3	0	2	9		
151	Independent events	11	1	3	0	2	9		
152	Dependent events	11	1	3	0	2	9		
153	Repeated trials of an event	11	1	3	0	2	9		
	21 *Determinants of Order N*								
154	Inversions	10	1	3	1	2	11		
155	Determinants of order n	7	3	4	1	2	13		
156	Minors of a determinant	7	3	2	3	2	14		
157	Properties of determinants	7	4	3	1	2	12		
158	Simplification of a determinants	7	4	1	2	2	12		
159	Systems of linear equations	7	4	2	2	2	13		
160	Matrices	10	1	2	1	3	12		
	22 *Partial Fractions*								
161	Definitions and theorems	13	0	2	1	1	6		
162	Distinct linear factors	13	0	2	1	1	6		
163	Repeated linear factors	13	0	2	1	1	6		
164	Distinct quadratic factors	13	0	2	1	1	6		
165	Repeated quadratic factors	13	0	2	1	1	6		
	23 *The Trigonometric Functions*								
166	Directed segments	4	0	0	7	6	21	*	
167	The distance formula	4	0	0	7	6	[illegible]1	*	
168	Trigonometric angles	3	0	0	5	9	24	*	
169	Standard position of an angle	1	0	0	5	11	35	**	
170	Definitions of the trigonometric functions	0	0	0	5	12	37	**	
171	Given one function, find the other functions	1	0	0	5	11	35	**	
	24 *Trigonometric Functions of An Acute Angle*								
172	Trigonometric functions of an acute angle	1	0	0	4	12	35	**	
173	CoFunctions	1	0	[illegible]	6	9	33	**	
174	Variation of the functions of an acute angle	1	0	0	5	11	35	**	
175	The trigonometric functions of 30°, 45°, 60°	1	0	0	3	13	36	**	
176	Tables of trigonometric functions	1	0	0	4	12	35	**	
177	Interpolation	1	0	1	5	10	34	**	
178	Approximations and significant figures	2	0	2	5	8	36	**	
179	The solution of right triangles	1	0	0	4	12	35	**	
180	Angles of elevation and depression	1	0	1	5	10	34	**	

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	25 *Trigonometric Identities*								
181	The fundamental relations	1	0	0	6	10	3 5	**	
182	Algebraic Operations	1	0	0	10	6	3 2	**	—
183	Identities and conditional equations	2	0	1	8	6	2 9	**	T
184	Trigonometric identities	1	0	0	11	5	3 1	**	
	26 *Related Angles*								
185	Related angles	1	0	1	7	8	3 2	**	
186	Reduction to functions of an acute angle	1	0	1	5	10	3 4	**	
187	Trigonometric functions of negative angles	1	0	0	6	10	3 4	**	
	27 *Radian Measure*								
188	The Radian	0	0	0	4	13	3 8	**	
189	Radians and degrees	0	0	0	4	13	3 8	**	
190	Length of a circular arc	0	0	0	6	11	3 6	**	
191	Trigonometric functions of numbers	1	0	3	5	8	3 3	**	
192	Linear and angular velocity	1	0	3	5	8	3 3	**	
	28 *Graphs of the Trigonometric Functions*								
193	Periodic functions	0	0	1	7	9	3 5	**	
194	Variations of the sine and cosine	0	0	1	5	11	3 6	**	
195	Variation of the tangent	0	0	3	7	7	3 2	**	
196	Graphs of the trigonometric functions	0	0	1	8	8	3 4	**	
	29 *Functions of Two Angles*								
197	Functions of the sum of two angles	1	0	1	9	6	3 1	**	
198	Sin (A + B) and Cos (A + B)	1	0	1	8	7	3 2	**	
199	Tan (A + B)	1	0	3	9	4	2 9	**	
200	Sin (A - B), Cos (A - B), and Tan (A - B)	1	0	3	6	7	3 1	**	
201	Reduction of a Sin θ + b Cos θ to K Sin (θ+H)	3	1	4	7	2	2 2	*	
202	Double-angle formulas	1	0	5	6	5	2 8	**	
203	Half-angle formulas	1	0	5	8	3	2 7	*	
204	Product to sum formulas, sum to product formulas	6	1	3	5	2	1 8	*	
	30 *Trigonometric Equations*								
205	Trigonometric equations	0	0	0	9	8	3 2	**	
206	Solving a trigonometric equation	1	0	0	8	8	3 3	**	
	31 *Graphical Methods*								
207	The Graph of y = a Sin bx	1	0	2	9	5	3 0	**	
208	The Graph of y = a Sin (bx + c)	1	0	2	9	5	3 0	**	
209	The Graph of y = Sin^n x	5	0	3	7	2	3 1	**	
210	Sketching curves by composition	4	1	4	5	3	2 1	*	
211	The graph of y = a Sin x + b Cos x	5	0	3	7	2	2 1	*	
	32 *Solution of Triangles*								
212	Solution of right triangles	2	0	0	5	10	3 2	**	
213	Vectors	1	0	1	7	8	3 2	**	
214	The law of sines	0	0	0	5	12	3 6	**	
215	Applications SAA	2	0	1	6	8	3 0	**	
216	The ambiguous case SSA	4	0	2	3	8	2 6	*	
217	The Law of Cosines	0	0	2	3	12	3 6	**	
218	Applications SAS and SSS	2	0	1	6	8	3 1	**	
219	The Area of a triangle	3	1	0	10	3	3 5	**	
	33 *Inverse Trigonometric Functions*								
220	Inverse trigonometric functions	2	0	1	7	7	3 0	**	
221	Principal values of the inverse trigonometric functions	2	0	3	5	7	2 9	**	
222	Operations involving inverse trigonometric functions	3	0	3	6	5	2 6	*	
223	Inverse functions	2	1	3	6	5	2 6	*	
	34 *Special Topics*								
224	The circular functions	7	1	3	4	2	1 6	*	
225	Circular and exponential functions	7	1	4	3	2	1 5	*	
226	Solving oblique triangles SAS and SSS	4	1	2	5	5	2 4	*	
227	The law of tangents	8	1	2	2	4	1 6	*	
228	Applications of the law of tangents SAS	9	1	2	3	2	1 3		
229	The half-angle formulas	5	0	4	4	4	2 1	*	
230	Applications of the half angle formulas: SSS	9	1	2	4	1	1 2		
231	The mil as a unit of angular measure	10	1	3	1	0	6		

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	35 Coordinates and Lines								
232	Number system	3	0	1	7	6	2.8	**	
233	Rectangular coordinates	1	0	0	6	10	3.4	**	
234	Distance between two points	2	0	0	5	10	2.8	**	
235	Point on the line joining two points	3	0	1	7	6	2.9	**	
236	Area of a triangle	3	0	2	5	7	2.8	**	
237	Inclination and slope	1	0	0	4	12	3.5	**	
238	Parallel and perpendicular lines	2	0	0	5	10	3.2	**	
239	Angle between two lines	4	1	3	1	8	2.5	*	
240	The locus of a point	4	0	1	5	7	2.9	**	
241	Equation of a straight line	2	0	0	4	11	3.3	**	
242	Standard equation of lines	[illegible]	0	0	4	10	3.1	**	
243	Intersection of lines	2	0	0	5	10	3.2	**	
244	Distance from a line to a point	4	0	2	7	4	2.4	*	
245	Family of lines	4	2	2	5	4	2.2	*	
246	Line through the intersection of two lines	3	1	2	6	5	2.5	*	
	36 Variables, Functions, and Limits								
247	Rate of change	2	0	0	8	7	3.1	**	
248	The concept of area	1	0	0	11	5	3.1	**	
249	Constants and variables	1	0	1	8	7	3.2	**	
250	Functions	1	0	1	8	7	3.2	**	
251	Limit of a function	1	0	0	11	5	3.1	**	
252	Continuity	2	0	2	11	2	2.6	*	
253	Infinity	2	0	2	11	2	2.6	*	
254	Limit of a sequence	2	1	5	6	3	2.4	*	
	37 Differentiation and Applications								
255	Increments	1	0	0	6	10	2.8	**	
256	Derivative	1	0	0	5	11	2.9	**	
257	Derivatives of powers of x	1	0	0	3	13	3.6	**	
258	Slop of a curve	1	0	0	5	11	3.5	**	
259	Velocity and acceleration	1	0	0	6	10	3.4	**	
260	Maxima and Minima	1	0	0	5	11	3.5	**	
261	Critical points	1	1	[illegible]	5	9	3.2	**	
262	Higher derivatives	1	1	[illegible]	6	8	3.[illegible]	**	
263	Points of inflection, concavity	[illegible]	1	0	5	9	3.2	**	
264	Applications of Maxima and Minima	1	0	0	5	11	3.5	**	
265	Differentials	3	0	2	8	4	2.6	*	
266	Approximations and errors	3	1	4	6	3	2.3	*	
	38 Integration of Algebraic Forms								
267	Antidifferentiation	[illegible]	0	1	6	9	3.3	**	
268	Integration of powers	[illegible]	0	0	4	12	3.5	**	
269	Constant of integration	1	0	0	7	9	3.4	**	
270	Differential of area	1	0	0	8	8	3.3	**	
271	Area as an integral	1	0	0	7	9	3.4	**	
272	Calculation of areas	[illegible]	0	1	6	9	3.3	**	
273	Area as a limit	2	0	1	8	6	2.9	**	
274	Definite integrals	1	0	0	8	8	3.3	**	
275	Fundamental theorem	3	0	6	6	2	2.2	*	
276	Plane areas in rectangular coordinates	2	0	1	7	7	3.0	**	
277	Volumes of solids of revolution	3	0	3	5	6	2.6	*	
	39 Applications of Integration								
278	Moment of mass, centroids	6	0	2	6	3	2.0	*	
279	Centroid of a plane area	5	0	4	5	3	2.1	*	
280	Centroid of a solid of revolution	7	0	5	3	2	1.6	*	
281	Moment of inertia	4	0	4	6	3	2.1	*	
282	Radius of gyration	5	0	4	5	3	2.1	*	
283	Moment of inertia of an area	6	0	4	4	3	1.9	*	
284	Moment of inertia of a solid of revolution	7	0	3	5	2	1.7	*	
285	Fluid pressure	5	3	2	5	2	1.6	*	
286	Work	3	1	2	7	3	2.0	*	
	40 Differentiation of Algebraic Functions								
287	Formulas for differentiation	1	0	0	6	10	2.2	*	
288	Differentiation of implicit functions	2	0	1	7	7	2.4	*	
	41 Equations of the Second Degree								
289	The graph of an equation	2	1	0	[illegible]	7	2.9	**	
290	Equations of the second degree	2	1	0	7	7	2.9	**	
291	The circle	3	0	0	6	8	2.9	**	
292	Circle determined by three conditions	3	0	3	7	4	2.4	*	
293	Radical axis	6	1	5	4	1	1.[illegible]		
294	The parabola	3	0	0	8	6	2.5	*	
295	Another construction of a parabola	5	2	7	2	1	1.2		
296	General equations of a parabola	1	2	1	6	7	2.6	*	
297	Parabolas determined by three conditions	4	1	4	6	2	1.5	*	
298	The ellipse	5	0	1	5	7	2.6	*	
299	Another construction of an ellipse	5	3	5	2	2	[illegible].4	*	

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300	General equations of an ellipse	2	1	1	6	7	25	•	1
301	Ellipses determined by four conditions	4	2	4	6	1	19	•	
302	The hyperbola	2	1	0	6	8	30	••	
303	Asymptotes	2	1	3	4	7	28	••	
304	General equations of a hyperbola	2	1	1	6	7	29	••	
305	Hyperbolas determined by four conditions	5	2	4	5	1	17	•	
306	Translation of axes	7	0	2	4	4	19	•	
307	Rotation of axes	9	1	5	1	1	11		
308	Line tangent to a conic	10	1	2	1	3	12		
309	Poles and polars	8	2	6	0	1	11		
310	Tangents to a conic	7	2	2	4	2	15	•	
	40 Differentiation of Transcendental Functions								
311	Transcendental functions	2	0	2	9	4	28	••	
312	Properties of trigonometric functions	2	0	6	5	4	25	•	
313	Limit of sin θ/θ	3	1	5	3	5	24	•	
314	Derivatives of trigonometric functions	[illegible]	0	1	8	6	29	••	
315	Properties of inverse trigonometric functions	5	1	3	4	4	24	•	
316	Derivatives of inverse trigonometric functions	5	0	3	5	4	22	•	
317	Exponential and logarithmic functions	3	1		6	5	26	•	
318	Derivatives of logarithmic functions	3	1	2	4	1	26	•	
319	Derivatives of exponential functions	3	1	2	4	1	25	•	
320	Summary and applications	2	1	4	4	5	26	•	
	41 Parametric equations, curvature, and [illegible]								
321	Parametric representation	1	0	2	3		0		
322	Derivatives in parametric form		0	1	2		9		
323	Differential of arc length	1	0		4				
324	Curvature	1	1		3		9		
325	Circle of curvature	12	2				6		
326	Center of curvature	12	2			1	6		
327	Evolutes	12	3	1	0		5		
328	Newton's method	13			0	2	6		
	44 [illegible]								
329	Time-rates	3	0	0	8	6	28	••	
330	Curvilinear motion	7	1	0	5	4	9	•	
331	Tangential and normal components of acceleration	7	0	0	6	4	20	•	
332	Angular velocity and acceleration	5	0	1	6	4	22	•	
	45 Polar Coordinates								
333	Polar coordinates	8	1	1	3	4	6	•	
334	Locus of a polar equation	10	1	1	3	2	2		
335	Intersection of polar curves	10	1	2	2	2			
336	Angle between the radius vector and tangent	12	1	2	2	0	6		
337	Differential of arc	13	0	2			6		
[illegible]	Curvature	12	0	1	4	0	6		
339	Radical and transverse components of velocity and ac[illegible]tion	13	0	3	0		6		
	46 Indeterminate Forms								
340	Limits	10		3	2		0		
341	Rolle's theorem	12	0	4	0		7		
342	Law of the mean		0	3	1	2	10		
343	Cauchy's theorem	13	0	3	0		6		
344	Treatment of indeterminate forms	[illegible]	0	3	2		8		
	47 Curve Tracing								
345	Graphs of curves in rectangular coordinates	2	1	1	9	4	27	•	
346	Oblique asymptotes determined by inspection	7	1	4	4	1	15	•	
347	Asymptotes to an algebraic curve	6	1	3	6		17	•	
348	Singular points of algebraic curves	7	0	3	5	2	17	•	
349	Summary of curve tracing	8	1	1	6	1	15	•	
	48 Integration								
350	Formulas of integration	2	0	1	7	1	29	••	
351	Integration of powers	1	1	0	6	9	26	•	
352	Integration of exponential functions	4	1	0	6	6	31	••	
353	Integration of trigonometric functions		1	1	7	7	31	••	
354	Transformations of trigonometric integrals	4	1	1	6	3	23	•	
355	Integrals giving inverse trigonometric functions	5	1	3	4	4	19	•	
356	Additional formulas of integration	6	1	2	4	4	19	•	
357	Improper integrals	6	2	3	5	1	15	•	
358	Integration by parts	6	0	4	4	3	19	•	
359	Algebraic substitutions	6	1	2	5	3	19	•	

Item No	Topic, by Concept Area	A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
		Frequency of Response, Topic Coverage							
360	Trigonometric substitutions	5	1	3	5	3	20	•	
361	Integration of rational fractions	8	1	1	3	4	16	•	
362	Miscellaneous substitutions	9	2	3	1	2	11		
363	Use of integration tables	3	4	3	3	4	23	•	
364	Approximate integration	5	4	3	2	3	16	•	
365	Trapezoidal rule	6	2	3	3	3	17	•	
366	Simpson's rule	8	1	3	3	2	13		
367	Area in polar coordinates	0	3	1	2	1	9		
368	Length of a plane curve	9	1	2	3	1	11		
369	Centroid and moment of inertia of arc	9	2	3	0	3	12		
370	Area of a surface of revolution	7	1	3	3	3	16	•	
371	Volumes of solids with known cross sections	7	1	2	3	4	19	•	
372	Average value	8	1	2	4	2	17	•	
	Infinite Series								
373	Sequences and series	9	1	3	2	2	12		
374	Convergent and divergent series	11	1	1	2	2	11		
375	Theorems on convergence	12	0	2	1	2	9		
376	The integral test	13	0		2	1	7		
377	Comparison tests	12		1	2		8		
378	Ratio test	12	1	1		2	8		
379	Alternating series	13	0	1	1	2	8		
380	Absolute and conditional convergence	13	0	1	1	2	8		
381	Power series	[illegible]	1	1	2	2	[illegible]		
	Expansion of Functions								
382	Maclaurin's series	10	0	[illegible]	4	[illegible]	14	•	
383	Algebraic operations with power series	10	1	1	3	2	2		
384	Differentiation and integration of power series	1			3		[illegible]		
385	Approximation formulas derived from power series	8	2	[illegible]	[illegible]		2		
386	Taylor's series	1	0		[illegible]	2			
387	Taylor's theorem	2		2			[illegible]		
	Hyperbolic Functions								
388	Definitions of the hyperbolic functions	11		2		2	9		
389	Identities involving hyperbolic functions	12	2	1			6		
390	Derivatives and integrals of hyperbolic functions	12	1	2	1		7		
391	The inverse hyperbolic functions	12		2			[illegible]		
392	Derivatives of the inverse hyperbolic functions	2	2	2	0		6		
393	Integrals leading to inverse hyperbolic functions	2		2			[illegible]		
394	Relations between trigonometric and hyperbolic functions	10	2	1	0		5		
395	Geometric interpretation of hyperbolic functions	3	2		0		5		
	[illegible] Analytic Geometry								
396	Rectangular coordinates	1	2	0	2	2	9		
397	Distance between two points	12	1	0	2	2	9		
398	Point on the line joining two points	3	0	0	2	2	8		
399	Direction of a line	12		0	2	2	9		
400	Angle between two lines	12		0	2	2	9		
401	Locus of a point in space	2		0	2	2	9		
402	Equation of a plane	4	0				[illegible]		
403	Normal equation of a plane	14		0			[illegible]		
404	Planes determined by three conditions	0			2	0	5		
405	Equations of a line	4	0		0	2	6		
406	Symmetric equations of a line	[illegible]	0		0	0	6		
407	Equation of a surface	15	0	0			4		
408	Quadric surfaces	15	0	0			4		
	Partial Differentiation								
409	Functions of two or more variables	2		0		0	8		
410	Continuity	2	3	0	1	1	6		
411	Partial derivatives			3		1	8		
412	Geometric interpretation of partial derivatives	[illegible]	2	0		[illegible]	5		
413	Partial derivatives of higher order	14	1	0			5		
414	Increment and total differential of a function	4	0	0	2		6		
415	Approximations and errors	14	0			1	5		
416	Total derivatives	14	0	0	2		6		
417	Chain rule for partial derivatives	4		0	1	1	5		
418	Differentiation of implicit functions	14	0	0	2	1	6		
419	Tangent line and normal plane to a curve	4	0	0	3	0	5		
420	Normal line and tangent plane to a surface	4	0	0	3	0	5		
421	Maxima and minima	14	0	2	0		[illegible]		
422	Differentiation of a definite integral	14	1	0		[illegible]	5		
423	Taylor's series for functions of two variables	16	0	0	1	0	2		
424	Sufficient condition for a maximum or minimum	14	2	0	0	[illegible]	4		

Item No	Topic, by Concept Area	Frequency of Resource, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
	54 *Multiple Integrals*								
425	Double integrals	13	0	1	2	1	7		
426	Iterated integrals	14	0	1	1	1	5		
427	Iterated integrals in rectangular coordinates	14	0	1	1	1	5		
428	Plane areas by double integration	13	0	1	2	1	7		
429	Centroid and moment of inertia of a plane area	14	0	1	1	1	5		
430	Iterated integrals in polar coordinates	13	0	3	0	1	6		
431	Plane areas in polar coordinates	14	1	1	0	1	4		
432	Volumes by double integration	14	0	1	1	1	5		
433	Volumes in cylindrical coordinates	14	1	1	0	1	4		
434	Areas of curved surfaces	14	0	1	1	1	5		
435	Triple integrals	13	1	2	0		5		
436	Iterated integrals	14	1	1	0		4		
437	Iterated triple integrals in rectangular coordinates	4	0	1	1	1	5		
438	Volumes by triple integration	13	0	3	0	1	6		
439	Center of gravity and moment of inertia of a solid	15	0		0		4		
440	Triple integrals in cylindrical coordinates	15	1	0	0		3		
441	Triple integrals in spherical coordinates	15		0	0	1	3		
	55 *Differential Equations*								
442	Solutions of differential equations	6	3	2	3	3	6	*	
443	Differential equations of first order and first degree	6	3	2	3	3	16	*	
444	Exact differential equations	8	2	3	3	1	12		
445	Linear equations of the first order	7	2	2	4	2	5	*	
446	Equations reducible to linear equations	11	0	1	3	2			
447	Second order equations/reducible to first order	11		1	3	1	9		
448	Applications of first order differential equations	9	2	1	4	1	2		
449	Linear differential equations of order n	11	1	2	1	2	9		
450	Homogeneous equations with constant coefficients	12	0	1	2	2	9		
451	Nonhomogeneous equations with constant coefficients	13	0	0	2	2	8		
452	Applications of linear differential equations	10	2	1	2	2			
	56 *Vector Analysis*								
453	Addition of Vectors	9	0	2	5	3	18	*	
454	Scalar multiplication of Vectors	7		2	3	4	18	*	
455	Vector multiplication of Vectors	9	1	2	2	3	14	*	
456	Scalar triple product	14	0	1	1	1	5		
457	Vector triple product	14	0	1	1	1	5		
458	Derivative of a vector	14	1	0	2	0	4		
459	The gradient	14	1	0	2	0	4		
460	The divergence	14	1	0	2	0	4		
461	The curl of rotation	14	1	0	2	0	4		
462	Summary of vector differentiation	13	1	1	2	0	9		
463	Line integrals	14	1	0	1	1	5		
464	Surface integrals	14	0	2	1	0	4		
465	Divergence theorem	14	1	1	1	0	4		
466	Stokes's theorem	14	1	1	1	0	4		

TABLE 16.--Relative Emphasis on 56 Concept Areas in Mathematics, Reported by 17 Institutions Offering Associate Degree Engineering Technology Curricula

	Areas Receiving Little or No Emphasis	Areas Receiving Moderate Emphasis	Areas Receiving Substantial Emphasis
Algebra	Mathematical Induction The Binomial Theorem Permutations and Combinations Probability Determinants of Order N Partial Fractions	The number Systems of Algebra Functions and Graphs Complex Numbers Higher Degree Equations Inequalities Ratio, Proportion, and Variation Progressions	The Fundamental Operations Special Products and Factoring Fractions Exponents and Radicals Linear and Fractional Equations Quadratic Equations Systems of Equations Elementary Determinants with Applications Logarithms
Trigonometry		Special Topics in Trigonometry	The Trigonometric Functions Trigonometric Functions of an acute angle Trigonometric Identities Related Angles Radian Measure Graphs of the Trigonometric Functions Functions of Two Angles Trigonometric Equations Graphical Methods Solution of Triangles Inverse Trigonometric Functions
Calculus	Parametric Equations, Curvature, and Roots Polar Coordinates Indeterminate Forms Infinite Series Expansion of Functions Hyperbolic Functions Solid Analytic Geometry Partial Differentiation Multiple Integrals Differential Equations Vector Analysis	Application of Integration Differentiation of Algebraic Functions Equations of the Second Degree Differentiation of Transcendental Functions Differentiation with Respect to Time Curve Tracing Integration	Coordinates and Lines Variables, Functions, and Limits Differentiation and Application Integration of Algebraic Forms

institutions can measure their relative effort in these courses. It must be emphasized, however, that Table 16 reflects *current practice,* not necessarily an ideal. Institutions establishing or revising courses should consider carefully their planned overall curriculum objectives, and institutions using these data for comparison purposes should be aware that many observers would deem modal current practice inadequate for contemporary needs.

CHEMISTRY

Some associate degree engineering technology curricula contain, as part of their physical science requirements, an introductory course in chemistry. An effort was made to identify the general characteristics of such courses by studying a limited sample. Courses which appeared in curricula entitled "chemical technology," "chemical engineering technology," "chemical laboratory technology," or the like were excluded from the sample; only courses which could be identified as intended for "non-majors" were considered. The results of the study are presented in the following paragraphs.

Nature of the Sample

The chemistry courses at only ten institutions are included in the analysis which follow. While others existed within the sample chosen, responses to the questionnaire were incomplete or late and had to be rejected. The ten institutions had a national distribution geographically. They consisted of nearly equal numbers of technical colleges (monotechnical institutes, polytechnical institutes as elsewhere defined) and comprehensive community colleges. Equal numbers of the courses appeared in curricula accredited by the Engineers' Council for Professional Development and in curricula not so accredited.

General Observations

Most often, the chemistry course considered here was one which carried 4 or 5 semester hours credit and included a laboratory. Only one of the ten examined was without laboratory; only three carried less than 4 semester credits, and two of these were at institutions on the "quarter" system and had either 4 or 5 quarter credits (approximately equivalent to 2 and 3 semester credits, respectively). The course title varied greatly: "Chemistry," "Introductory Chemistry," "Technical Chemistry," and "Fundamentals of Chemistry" were among those used. In two cases, the catalog descriptions implied that students were excused from the course if they had successfully completed high school chemistry with a grade of "C or better"; such students substituted an elective for this course.

Many associate degree engineering technology curricula at the institutions visited did not include the chemistry course even though it was required in other curricula at the same school. Faculty members and program administrators, questionned on this point, responded that there was "no room" in the curriculum or that "other subjects have a higher priority." Questioned on the desirability of a chemistry course as a part of an engineering technology curriculum, these same faculty members gave responses which varied from "...not necessary..." to "...should be required for everybody"; student reactions to the same question ranged from "...I don't understand the need for it..." to "...I think I should have more."

The chemistry course most often was one open to students in several different programs at the college; for example, students in nursing, forestry, home economics, dental hygiene, and engineering technology were simultaneously enrolled in the chemistry class at one institution. In some cases, this chemistry course could be used to satisfy an institutional requirement for a laboratory science in the general curriculum. In a few instances, however, institutional practice was to restrict enrollment in the course to engineering technology students only.

Topic Coverage

The questionnaire related to topic coverage in chemistry (Appendix C) contained 85 items. Table 17 gives a summary of the responses. It is interesting that only 18 of the 85 topics showed a difference in practice by technical colleges and comprehensive community colleges. A possible explanation exists for why Items 61-63, 65-68, and 72--topics which are strongly physics-related--appear to be emphasized to a greater extent in comprehensive community colleges than in technical colleges. Quite often, enrollment in the chemistry course in community colleges is "open," that is, the course serves individuals in many disciplines. Since some of these students may not subsequently study physics, it may be important, therefore, that these particular physics-related topics be given emphasis. In technical colleges, on the other hand, enrollment is more often restricted and nearly all students will subsequently study physics; hence, it may seem less important to emphasize these special topics in the chemistry course.

TABLE 17.--Coverege Given to Selected Topics in the Chemistry Course Intended for Students in Associate Degree Engineering Technology Programs

Item No	Topic	Frequency of Response, Topic Coverage					Item Score	Relative Emphasis	Emphasis Difference
		A	B	C	D	E			
1	Classification of matter	0	0	3	5	2	2 9	**	
2	Weight relations, conservation laws	0	1	1	3	5	3 2	**	
3	Physical & Chemical Changes	0	1	1	3	5	3 2	**	
4	Chemical notation	0	1	1	1	[illegible]	3 4	**	
5	Atomic and Formula Weight	0	1	1	1	7	3 4	**	
6	Chemical equations and Stoichiometry	0	1	1	1	7	3 4	**	
7	Kinds of Elements	0	0	3	4	3	3 0	**	
8	Descriptive Study of certain representative elements	0	0	4	6	0	2 6	*	
9	Binary Compounds	0	2	3	2	3	2 6	*	
10	Ternary Compounds	0	3	2	3	2	2 4	*	
11	Fundamental Particles	0	2	2	3	2	2 7	*	T
12	Nuclear Reactions	0	6	2	2	0	1 6	*	
13	Natural Radioactivity	0	4	4	2	0	1 8	*	
14	Artificial Radioactivity	2	3	3	2	0	1.5	*	C-
15	Fission and Fusion	1	3	5	1	0	1 6	*	
16	Periodic Law	0	1	2	1	6	3 2	**	
17	Atomic Structure	0	0	2	1	7	3 8	**	
18	Stable Electron Configurations	0	2	1	1	6	3 2	**	
19	Aklali Metals	0	2	2	6	0	2 4	*	
20	Metals of Groups IIA and IIIA	0	2	3	5	0	2 3	*	
21	Elements of Groups VIA and VIIA	1	1	3	5	0	2 2	*	
22	Transition Elements	1	1	5	2	1	2 1	*	
23	Elements of Groups IVA and VA	0	1	5	4	0	2 3	*	
24	Ionic Bond	0	2	0	[illegible]	5	3 1	**	
25	Simple and Complex Ions	1	1	1	3	4	2 8	**	
26	Electrolysis	0	1	2	1	7	3 2	**	
27	Covalent Bond	0	1	1	3	5	3 2	**	
28	Structure of the Hydrogen Molecule	0	1	2	4	3	2 9	**	
29	Other Diatomic Molecules	0	0	3	5	2	2 9	**	
30	Covalent Bonds between Dissimilar Atoms	0	2	1	4	3	2 8	**	
31	Properties of Covalent Compounds	0	2	1	3	4	2 9	**	
32	Solvent-Solute Phenomena	1	1	1	1	6	3 2	**	
33	Molality	1	2	1	1	5	2 7	*	
34	Freezing Point Depression and Boiling Point Elevation Calculations	1	2	0	1	6	2 9	**	
35	Partially Ionic Bonds	0	2	3	1	4	2 7	*	
36	Partially Covalent Bonds	0	2	3	1	4	2 7	*	
37	Electronegativity	0	2	2	2	4	2 8	**	
38	Structure of Partially Ionic-Partially Covalent Compounds	1	3	1	2	3	2 4	*	
39	Dipolar Molecules	1	1	2	2	4	2 7	*	C
40	Ionization of Polar Molecules	0	3	1	2	4	2 7	*	
41	Hydrogen Bonding	1	2	2	2	3	2 4	*	
42	Redox Reactions of the Free Elements	0	4	1	2	3	2 4	*	
43	Redox Reactions of Compounds	0	4	0	3	3	2 5	*	
44	Oxidation Numbers	2	1	0	1	6	2 8	**	
45	Balancing Redox Equations	2	1	1	3	3	2 4	*	
46	Activity Series	1	3	0	2	4	2 5	*	
47	Redox Equilibria	3	3	0	1	3	1 8	*	

Item No.	Topic	Frequency of Response, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
48	Arrhenius Concept of Acids and Bases	3	0	1	4	2	22	*	C
49	Bronsted-Lowry Concept of Acids and Bases	1	4	0	3	2	21	*	
50	Lewis Concept of Acids and Bases	4	2	0	2	2	16	*	
51	Strengths of Acids and Bases	1	3	0	1	5	26	*	
52	Hydrolysis of Salts	0	4	2	2	2	22	*	C
53	Titration	2	1	1	3	3	24	*	C
54	Normal and Molar Concentration	1	2	1	2	4	26	*	
55	Indicators	3	0	2	4	1	20	*	
56	Acidic, Basic, and Amphoteric Oxides	1	1	3	3	2	24	*	
57	Acid-Base Equilibria	2	1	3	0	4	23	*	
58	pH Calculations	2	2	1	2	3	22	*	C
59	Liquids - Gases - Solutions	0	2	2	3	3	27	*	C
60	Van der Waals, Ionic Covalent, and Metallic Solids	2	2	1	2	3	22	[illegible]	C
61	Boyle's Law Calculations	1	1	1	3	4	28	**	C
62	Charles' Law Calculations	1	1	1	3	4	28	**	C
63	Ideal Gas Law Calculations	1	1	1	4	3	27	*	C
64	Forms of Energy	1	2	0	4	3	26	*	
65	Specific Heat	3	1	1	2	3	21	*	C
66	Heat of Fusion	3	0	0	4	3	24	*	C
67	Heat of Vaporization	2	1	0	4	3	25	*	C
68	Kinetic-Molecular Theory	0	3	0	4	3	27	*	C
69	Bond Energies	2	1	2	2	3	23	*	
70	Heat of Reaction	2	1	2	2	3	23	*	C
71	Activation energy	2	1	3	2	2	21	*	
72	Free Energy	3	2	1	2	2	18	*	C
73	Enthalphy and Entrophy	2	4	0	2	2	18	*	
74	Hydrocarbons	4	2	2	2	0	12		
75	Aliphatic Hydrocarbons	5	1	3	1	0	10		
76	Aromatic Hydrocarbons	4	3	3	0	0	9		
77	Reactions of Hydrocarbons	4	2	4	0	0	10		
78	Functionally Substituted Hydrocarbons	6	0	4	0	0	8		
79	Reactions of Substituted Hydrocarbons	6	2	2	0	0	6		
80	Ionic Organic Mechanisms	7	2	1	0	0	4		
81	Free Radical Organic Mechanisms	8	1	1	0	0	3		
82	Sugars and Polysaccharides	6	2	2	0	0	6		
83	Fats	6	2	2	0	0	6		
84	Amino Acids and Proteins	6	2	[illegible]	0	0	6		
85	Vitamins and Alkaloids	7	2	1	0	0	4		

Comments

It is sometimes dangerous to assume that "general practice" or "modal behavior" provides a suitable criterion by which to evaluate existing educational programs or can serve as a model after which new programs may best be patterned. On the other hand, some useful purposes can perhaps be served by examining critically these general comments about the chemistry course for non-majors which may appear in an associate degree engineering technology curriculum:

1. It normally carries 4 or 5 semester credits.
2. It includes a laboratory.
3. It can serve disciplines other than engineering technology.
4. It need not be based on previous high school study of chemistry.
5. Topics related to organic chemistry (see Items 74-85, Table 17) are considered of much lesser importance than topics related to inorganic chemistry.
6. Topics related to terminology and nomenclature (Topics 1-10), to concepts of atomic structure and periodicity (Topics 16-18), and to chemical bonding (Topics 24-37) appear to be considered of primary importance in the syllabus; topics of a more descriptive and less theoretical nature appear to be considered relatively less important.

Institutions establishing chemistry courses intended for engineering technology students should consider the above comments as initial constraints on the course offering--adapting these constraints, however, to fit local needs. Institutions offering the third and fourth year of a baccalaureate engineering technology program and accepting transfers from associate degree programs should be aware of the kind of experience in chemistry which most such transfer students will have had. And, institutions offering associate degree engineering technology programs which include a chemistry course can use the foregoing descriptions as crude and superficial measures against which they may assess their own performance.

PHYSICS

Almost all associate degree engineering technology curricula contain courses in physics. A study to determine the general characteristics of such courses has been made, the results of which are described in the following sections.

Nature of the Sample

The physics courses at 14 institutions are discussed. The original sample contained more institutions, but many responses were incomplete or late and, hence, were rejected. The institutions contributing usable responses were representative of all regions of the country and were equally distributed by type, that is, technical colleges and comprehensive community colleges. The Engineers' Council for Professional Development had accredited one or more engineering technology curricula at 8 of these institutions; 6 of the institutions offered curricula not so accredited.

General Observations

The physics sequence for engineering technology curricula most often consists of two courses, each carrying 4 semester credits; these courses consist usually of three lecture periods and a laboratory. Variations in this pattern range from a single course to a sequence of three 5-credit courses. The course titles were usually listed as "Physics" or "Technical Physics". Commonly, a numerical sequence designator (Physics I, Physics II, etc.) was employed. The catalog descriptions frequently implied that the sequence was open only to technical students, and sometimes cautioned that the sequence was not acceptable as part of the requirements of a "transfer" program. Co- or prerequisites of algebra and trigonometry were often listed; in none of the cases studied was calculus listed as a prerequisite.

Topic Coverage

The questionnaire related to topic coverage in physics (Appendix D) contained 242 items in six major concept areas. Table 18 gives data on the relative emphasis given to these topics, as reported by the respondents.

It can be noted from the table that most topics received "moderate" or "substantial" emphasis, with the exception of topics in the concept area of Modern Physics. Topic coverage practices apparently did not differ appreciable between technical colleges and comprehensive community colleges; significant differences were detected for only 11 items out of the 242, less than 5 percent. A summary of the relative emphasis given to various topics in the six major concept areas of physics appears in Table 19.

TABLE 18 --Coverage Given to Selected Topics in the Physics Course Sequence Intended for Students in Associate Degree Engineering Technology Programs

Item No	Topic, by Concept Area	Frequency of Response, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
	1 Mechanics								
1	Units and Systems of Measurement	0	1	2	7	4	3.0	**	
2	Vector quantities	0	1	1	6	6	3.2	**	
3	Representation of Vector quantities	0	1	1	7	5	3.1	**	
4	Vector addition	0	1	1	6	6	3.2	**	
5	Vector subtraction	0	2	1	8	3	2.9	**	T
6	Resolution of Vectors	0	0	2	6	6	3.3	**	
7	Component method of Vector addition	0	0	2	6	6	3.3	**	
8	Constant, Instantaneous, and Average Speed	0	1	1	7	5	3.1	**	
9	Speed and velocity	0	0	1	6	7	3.4	**	
10	Acceleration	0	0	0	7	7	3.5	**	
11	Kinematics equations	1	0	1	6	6	3.1	**	
12	Falling bodies	0	0	1	7	6	3.4	**	
13	Motion in a vertical plane	0	0	2	7	5	3.2	**	
14	Projectile and Rocket flight	0	1	1	7	5	3.1	**	
15	Laws of motion	0	0	2	5	7	3.4	**	
16	First law of motion	0	0	2	6	6	3.3	**	
17	Second law of motion	0	0	2	5	7	3.4	**	
18	Third law of motion	0	0	2	6	6	3.3	**	
19	Inertia and m[illegible]	0	1	2	7	4	3.0	**	
20	Force and mo[illegible]	0	0	2	5	7	3.4	**	
21	Mass and we[illegible]	0	0	3	6	5	3.1	**	
22	Sliding friction	0	1	[illegible]	7	5	3.1	**	
23	Coefficient of friction	0	1	1	7	5	3.1	**	
24	Static friction	1	0	2	7	4	2.9	**	
25	Rolling friction	1	1	5	5	2	2.4	*	
26	Fluid friction	3	5	4	2	0	1.4	*	
27	Equilibrium of a particle	1	1	0	8	4	2.9	**	
28	Torque	0	1	1	8	4	3.1	**	
29	Center of gravity	0	2	4	6	2	2.6	*	
30	Uniform circular motion	0	0	5	4	5	3.0	**	
31	Centripetal acceleration	2	0	2	5	5	2.8	**	
32	Centripetal force	1	0	3	5	5	2.9	**	
33	Banked turns	2	1	3	7	1	2.3	*	
34	Centrifugal force	3	1	3	4	3	2.2	*	
35	Gravitation	1	2	3	5	3	2.4	*	
36	Gravitational field	1	2	8	3	0	1.9	*	
37	Energy, definitions	0	0	3	6	5	3.4	**	
38	Work	0	0	2	6	6	3.3	**	
39	Power	0	0	2	6	6	3.3	**	
40	Power measurement	0	1	2	8	3	2.9	**	
41	Kinetic energy	0	0	2	8	4	3.1	**	
42	Potential energy	0	0	2	6	6	3.3	**	
43	Conservation of energy	0	0	2	7	5	3.2	**	
44	Momentum and impulse	0	2	1	6	5	3.0	**	
45	Conservation of momentum	0	2	1	5	6	3.1	**	
46	Collisions	1	1	2	5	5	2.9	**	
47	Angular measurement	0	3	1	6	4	2.8	**	
48	Angular velocity	0	3	2	4	5	2.8	**	
49	Angular acceleration	0	3	2	4	5	2.8	**	
50	Kinematics of Angular motion	1	3	2	6	3	2.6	*	
51	Rotational kinetic energy	1	2	3	5	3	2.5	*	
52	Moment of inertia	0	3	2	5	4	2.7	*	
53	Torque and angular acceleration	1	1	2	6	4	2.8	**	
54	Angular momentum	2	1	3	6	2	2.4	*	
55	Simple Machines	2	1	2	6	[illegible]	2.5	*	
56	Mechanical advantage	2	2	2	5	3	2.4	*	
57	Efficiency	1	2	2	4	5	2.6	*	
58	Density	1	0	4	6	3	2.7	*	
59	Elasticity	0	1	3	6	4	2.9	**	
60	Young's modulus	0	1	4	5	4	2.9	**	
61	Shear modulus	2	3	4	4	1	2.6	*	
62	Bulk modulus	2	4	3	4	1	1.9	*	
63	Pressure	0	0	3	7	4	2.4	*	
64	Hydraulic press	2	2	3	4	3	2.3	*	
65	Pressure and depth	1	0	4	5	4	2.8	**	
66	Archimedes' principle	2	0	7	1	4	2.4	*	
67	Fluid flow	2	2	5	[illegible]	1	2.0	*	
68	Bernoulli's equation	2	3	5	3	1	1.9	*	
69	Elastic potential energy	3	1	6	4	0	1.8	*	
70	Simple harmonic motion	4	0	3	5	2	2.8	**	
71	The pendulum	3	3	2	4	2	1.9	*	
72	Kinematics of vibratory motion	5	0	4	3	2	1.8	*	
	2 Wave Motion, Acoustics								
73	Water waves	4	3	3	4	0	1.5	*	
74	Longitudinal and transverse waves	1	0	5	4	4	2.7	*	
75	Wave speed and energy	2	3	3	3	3	2.1	*	
76	Standing waves	2	3	4	3	2	2.0	*	
77	Resonance	2	1	4	3	4	2.4	*	
78	Sound	2	1	5	1	5	2.4	*	
79	Musical Sounds	3	6	2	2	1	1.4	*	
80	Acoustical attenuation	7	1	5	[illegible]	0	1.0		
81	Supersonic waves	6	3	[illegible]	1	0	1.0		
82	Doppler effect	3	1	3	5	2	2.1	*	

Item No	Topic, by Concept Area	Frequency of Response, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
	3 Heat								
83	Temperature	0	1	2	6	5	31	**	
84	Heat	0	1	2	6	5	31	**	
85	Specific heat capacity	0	1	3	4	6	31	**	
86	Change of state	1	1	1	5	6	30	**	
87	Calorimetry	1	0	3	6	4	29	**	
88	Mechanical equivalent of heat	0	2	3	3	6	29	**	
89	Thermal expansion	0	0	3	6	5	30	**	
90	Volume expansion	0	0	5	5	4	29	**	
91	Boyle's law	1	1	2	6	4	28	**	
92	Charles' law	1	1	2	6	4	28	**	
93	Ideal gas law	1	1	2	6	4	28	**	
94	Kinetic theory of gases	1	4	4	3	2	21	*	
95	Kinetic theory of matter	2	6	2	3	1	14	*	
96	First law of thermodynamics	1	2	4	3	4	25	*	
97	Second law of thermodynamics	1	3	3	3	4	24	*	
98	Carnot engine	3	5	3	2	1	15	*	C
99	Carnot efficiency	3	5	3	3	0	14	*	C
100	Steam engines	4	4	5	1	0	12		C
101	Internal combustion engines	5	3	5	1	0	11		C
102	Statistical mechanics	10	1	3	0	0	5		
103	Conduction	0	2	4	4	4	27	*	
104	Convection	0	3	5	3	3	24	*	
105	Radiation	1	2	4	4	3	24	*	
106	The refrigerator	4	4	2	2	1	13		
107	Thermodynamics of refrigeration	6	3	3	2	0	11		
	4 Light, Optics								
108	Huygen's principle	2	4	2	3	3	21	*	
109	Reflection	0	2	1	5	6	31	**	
110	Plane mirror	0	1	2	5	6	31	**	
111	Concave mirror	1	0	3	5	5	29	**	
112	Convex mirror	1	0	3	5	5	29	**	
113	Image formation	1	0	2	6	5	30	**	
114	Mirror equation	2	0	2	5	5	28	**	
115	Magnification	1	0	3	5	5	29	**	
~~116~~	~~Spherical aberration~~	~~3~~	~~2~~	~~4~~	~~2~~	~~3~~	~~2[illegible]~~	~~*~~	
117	Snell's law	2	2	2	4	4	[illegible]	*	C
118	Index of refraction	0	1	3	5	5	[illegible]	**	
119	Apparent depth	4	2	3	3	2	[illegible]	*	
120	Total internal reflection	3	1	4	3	3	[illegible]	*	C
121	Lenses	1	2	3	4	4	26	*	
122	Image formation	1	2	2	4	5	27	*	
123	The lens equation	3	0	2	4	5	26	*	C
124	The eye	6	0	2	4	2	17	*	
125	The microscope	5	1	4	3	1	16	*	
126	The telescope	4	2	4	2	2	16	*	
127	Lens aberrations	2	4	5	2	1	17	*	
128	Diffraction	2	2	5	2	3	21	*	
129	The double slit	6	1	4	2	1	14	*	C
130	Color, Spectra and Spectrometry	1	4	3	3	3	22	*	
131	Diffraction grating	3	3	4	1	3	19	*	
132	Polarization	2	2	6	2	2	20	*	
	5 Electricity and Magnetism								
133	Electric charge	2	0	2	6	4	27	*	
134	Coulomb's law	2	0	2	6	4	27	*	
135	Multiple charges	3	1	2	4	4	24	*	
136	The electric field	2	0	2	6	4	27	*	
137	Electric field of a point charge	3	1	2	5	3	23	*	
138	Electric lines of force	2	2	2	5	3	24	*	
139	Potential difference	2	0	4	3	5	25	*	
140	Electric current	2	0	3	3	6	28	**	
141	Ohm's law	2	0	1	4	7	30	**	
142	Resistivity	2	0	3	4	5	27	*	
143	Resistors in combination	2	0	1	5	6	29	**	
144	Electrical power	2	0	1	5	6	29	**	
145	Electromotive force	2	0	2	5	5	28	**	
146	Kirchhoff's rules	3	[illegible]	3	3	4	23	*	
147	Ionization and recombination	5	4	3	1	1	12		
148	Polar molecules	9	1	3	1	0	7		
149	Electrolysis	6	3	3	0	2	12		
150	Electrochemical equivalent and electrodeposition	8	1	2	0	3	12		
151	Chemical sources of electric energy	3	4	1	5	1	18	*	
152	Dry batteries	2	3	2	4	3	22	*	
153	Storage batteries	3	2	2	4	3	21	*	
15[illegible]	Fuel cells	9	1	2	2	0	8		
15[illegible]	Capacitance	3	1	3	3	4	23	*	
156	Energy of a charged capacitor	3	1	4	2	4	22	*	
157	Electric energy density	4	1	4	5	0	17	*	
158	Dielectric constant	5	1	3	3	2	16	*	
159	Charging a capacitor	3	3	3	2	3	19	*	
160	Oersted's experiment	3	3	3	3	2	19	*	
161	Magnetic induction	2	0	2	7	3	26	*	
162	Magnetic field of a current	2	0	1	7	4	28	**	
163	Magnetic properties of matter	2	4	1	4	3	21	*	
164	Magnetic intensity	2	2	3	5	2	22	*	
165	Hysteresis	2	3	3	4	2	21	*	
166	Force on a current	2	0	3	5	4	26	*	
167	Force between two currents	[illegible]	0	3	3	4	22	*	
168	Behavior of charged particles in a magnetic field	3	0	3	5	3	24	*	

Item No	Topic, by Concept Area	Frequency of Response, Topic Coverage A	B	C	D	E	Item Score	Relative Emphasis	Emphasis Difference
169	Force on a current loop	3	1	4	3	3	2 1	*	
170	Galvanometer	3	1	3	2	5	2 4	*	
171	Ammeter	3	0	3	3	5	2 5	*	
172	Voltmeter	3	0	2	4	5	2 6	*	
173	DC electric motor	4	1	2	4	3	2 1	*	
174	Magnetic poles	3	2	2	4	3	2 1	*	
175	Faraday's law	4	0	3	3	4	2 2	*	
176	The betatron	9	5	1	0	0	5		
177	Moving wire in a magnetic field	2	1	2	5	4	2 6	*	
178	AC-generator	2	3	2	3	4	2 3	*	
179	DC-generator	2	2	3	3	4	2 4	*	
180	Back emf	3	2	3	2	4	2 1	*	
181	Transformer	3	2	2	2	5	2 3	*	
182	Inductance	2	1	1	4	6	2 8	**	
183	Solenoid	3	1	4	3	3	2.1	*	
184	Growth and decay of current	4	2	6	1	1	1 5	*	
185	Magnetic potential energy	6	3	3	1	1	1 6	*	
186	Magnetic energy densi[illegible]	6	4	4	0	0	9		
187	Electrical oscillations	4	3	5	1	1	1 4	*	
188	Effective current and voltage	2	2	3	4	3	2 3	*	
189	Phase relations	2	2	3	3	4	2 4	*	
190	Inductive reactance	3	2	2	2	5	2 3	*	
191	Capacitive reactance	3	1	3	2	5	2 4	*	
192	Impedance	3	2	1	3	5	2 2	*	
193	Resonance	3	3	1	2	5	2 1	*	
194	Power in AC-circuits	2	1	3	4	4	2 5	*	
195	Maxwell's hypothesis	9	3	1	1	0	6		
196	Electromagnetic waves	4	6	1	1	2	1 4	*	
197	Varieties of electromagnetic waves	6	4	1	1	2	1 2		
198	Electromagnetic waves in communications	7	4	1	2	0	9		
199	Radiation pressure	11	2	1	0	0	3		
	E Modern Physics								
200	Frames of reference	10	1	1	2	0	6		
201	Special theory of relativity	8	1	3		1	1 0		
202	Relativity and mass	7	3	2	2	0	9		
203	Mass and energy	3	5	2	3	1	1 6	*	
204	Photoelectric effect	5	3	0	3	2	1 4	*	C
205	Quantum theory of light	5	3	0	5	1	1 6	*	
206	X-rays	4	4	2	3	1	1 5	*	
207	Matter waves	9	1	3	1	0	7		
208	Uncertainty principle	7	3	3	0	1	9		
209	Causality	13	1	0	0	0	1		
210	The Nuclear model of the atom	5	1	3	5	0	1 6	*	
211	Electron orbits	7	1	1	4	1	1 4	*	
212	Atomic spectra	8	1	1	2	2	1 2		
213	Bohr atom	6	3	1	1	3	1 4	*	
214	Energy levels and spectra	7	2	1	2	2	1 3		-C
215	Atomic excitation	8	1	1	1	3	1 3		
216	Quantum theory of the atom	9	0	1	3	1	1 1		
217	Electron spin	8	0	3	2	1	1 1		
218	Periodic law	8	2	3	0	1	9		
219	Atomic structure	6	2	5	0	1	1 1		
220	Ionic binding	6	3	3	1	1	1 1		
221	Covalent binding	8	3	2	0	1	8		
222	Polar molecules	10	1	2	0	1	6		
223	Structure of solids	9	2	2	0	1	7		
224	Van der Waal's bonds	6	5	2	0	1	9		
225	Metallic bond	9	3	1	0	1	6		
226	Energy bands	9	2	2	0	1	7		
227	Impurity semiconductors	9	2	3	0	0	6		
228	Semiconductor devices	9	2	[illegible]	0	0	6		
229	Ferromagnetism	6	1	3	3	1	1 4		
230	Mass spectrometer	10	0	2	2	0	7		
231	Nucl[illegible]s	9	2	2	1	0	6		
232	Isotopes	5	4	2	1	2	1 4		
233	Binding energy	9	2	3	0	0	[illegible]		
234	Nuclear forces	8	1	4	1	0	9		
235	Radioactivity	3	3	5	2	1	1 6	*	
236	Half-life	6	2	4	1	1	1 2		
237	Nuclear reactions	7	2	3	1	1	1 1		
238	Nuclear fission	7	2	3	1	1	1 1		
239	Nuclear reactors	8	1	3	2	0	9		
240	Nuclear fusion	7	2	3	1	1	1 1		
241	The neutrino	9	3	2			5		
242	Antiparticles	8	5	1			5		

TABLE 19.--Relative Emphasis on Various Topics in Physics, Reported for Existing Courses in Associate Degree Engineering Technology Curricula.

	Topics Receiving Little or No Emphasis	Topics Receiving Moderate Emphasis	Topics Receiving Substantial Emphasis
MECHANICS		Friction Circular Motion Gravitation Angular Kinematics Vibratory Kinematics Simple Machines Hydrostatics Hydrodynamics	Systems of Measurement Vector Quantities Computations with Vector Quantities Linear Kinematics Newton's Laws Equilibrium of a Particle Energy Momentum Angular Velocity Simple Harmonic Motion Elasticity
WAVE MOTION ACOUSTICS	Musical Sounds Acoustics and Acoustical Attenuation Supersonic Waves	Longetudinal and Transverse waves Standing Waves Resonance Sound Phenomena	
HEAT	Heat Engines Statistical Mechanics Refrigeration	Kinetic Theory of Gases Thermodynamics Carnot Engines Conduction Convection Radiation	Temperature Specific Heat Change of State Calorimetry Thermal Expansion Gas Laws
LIGHT OPTICS		Huygen's Principle Snell's Law and Applications Optical Devices Diffraction Color Spectra, Spectroscopy Polarization	Geometric Optics, Reflection and Refraction
ELECTRICITY AND MAGNETISM	Electrolysis Maxwell's Equations Communications Circuits Radiation Pressure	Electrostatics Kirchoff's Rules Batteries and Cells Capacitors and Capacitance Magnetic Properties of Matter Electrical Instruments Electrical Machines Alternating Currents Electromagnetic Waves	Electric Current Ohm's Law Resistor Networks Electromotive force Electromagnetism Electromagnetic Forces Inductance
MODERN PHYSICS	Relativity Uncertainty Atomic Spectra Atomic Structure Structure of Solids Semiconductors Nucleons and Nuclear Forces Nuclear Reactions Neutrinos, mesons, other Fundamental Particles Antiparticles	Elementary Quantum Theory Nuclear Model of the Atom Electron Orbits Isotopes Radioactivity	

Comments

The tables in this section have illustrated current practice by selected institutions in the coverage given to topics normally found in a sequence of introductory college physics courses. As such, they provide (1) a crude model after which new courses may be fashioned, and (2) a criterion against which institutions may evaluate their individual practices. It must be remembered, however, that modal practice does not necessarily represent an ideal; therefore, suitable caution should be exercised in the interpretation of the results shown here. Many observers, for example, feel that physics, as a basic science, has certain enduring attributes not as susceptable to obselescence as specialized technical studies; hence, these observers urge that physics topics be given a greater coverage than is currently the case. Others, of course, take a somewhat contrary position, maintaining that the needed concepts of physics can best be included in technical courses; these observers urge that engineering technology curricula focus more directly on specialized technology and less on general background material such as physics.

Summary

A study of the mathematics, chemistry, and physics courses offered by selected institutions has been made. The results include descriptions of these courses as usually offered, data on the relative emphasis given to various topics in these courses, and comments on differences in practice--if any--between technical colleges and comprehensive community colleges.

The results are potentially useful to institutions inaugurating, revising, or accepting transfer of courses in engineering technology curricula.

CHAPTER 5

ACCREDITATION OF ENGINEERING TECHNOLOGY CURRICULA

CHAPTER 5

ACCREDITATION OF ENGINEERING TECHNOLOGY CURRICULA

The purposes of this paper are to give a brief overview of the process of accreditation, to review the histroy of accreditation of engineering technology curricula, to summarize certain data related to accreditation of engineering technology, and to call attention to some current issues in this area.

Introduction

Accreditation has been defined as "the process whereby an organization or agency recognizes a college or university or a program of study as having met certain predetermined qualifications or standards."[1] The Engineers' Council for Professional Development, 345 East 47th Street, New York, N.Y. 10017, is the agency responsible for accrediting programs of study in both engineering and engineering technology; ECPD states as its purpose the following: "To promote and advance all phases of engineering education with a view to the promotion of the public welfare through the development of the better educated engineer, engineering technician and engineering technologist."[2] The accreditation of an engineering technology curriculum thus assures students, potential students, parents, employers, government agencies, educational institutions, and the general public that certain minimum standards of quality are met by the program. ECPD regularly publishes list of curricula which have been accredited.[3]

Overview of Accreditation

Accreditation is a phenomenon peculiar to American education and evolved primarily because of the lack in the United States of a central or Federal control over educational institutions, a circumstance quite different from that prevailing in most other countries. In this

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[1]William K. Selden, *Accreditation, A Struggle Over Standards in Higher Education* (New York: Harper and Brothers, 1960), p.6.

[2]Engineers' Council for Professional Development, *Thirty-Eighth Annual Report* (New York: The Council, 1970), p.35.

For the 1970-71 list, see *Ibid*, pp.87-90.

country, education is a matter constitutionally reserved to the states which consequently have authority to charter and regulate both public and private institutions. However, the several states historically did not generally exercise the regulatory powers potentially available to them, with the result that institutions differing widely in character and quality evolved. Concern on the part of educators and others both about the general quality of institutions and about the standards of specific programs for the preparation of professionals led to the development of accreditation practices.[1] Currently, six regional associations and approximately thirty professional agencies are engaged in accrediting activities.[2]

The regional associations were established at various times in the period from 1885 to 1924. Table 20 includes the founding dates of these bodies. The major objective of the various regional associations when they were first founded was to establish suitable and consistent college admissions criteria. In the nineteenth and early twentieth centuries, graduates of secondary schools who applied for college entrance often varied widely in their qualifications, and admissions officers were often perplexed about ways to place entering students properly. The early activities of the regional associations resulted in substantial improvement in the quality of weaker high schools and a standardization of the curriculum of all. After a measure of articulation between secondary and college programs was thus achieved, the associations then turned their attention to collegiate institutions since these, too, varied considerably in quality and level. The regional associations initially operated by setting rather specific standards relating to such aspects of an institution as its chartering, organization and administration, admission requirements, library facilities, curriculum patterns, and physical facilities, and then evaluating the institution by those standards. The associations provided a valuable service to the public by identifying institutions of quality; they tended thus to eliminate weaker--or fraudulent--schools. In recent years, the emphasis of the regional associations in their accrediting activities has shifted away from the application of quantitative "minimum standards" toward the use of broader, qualitative criteria

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[1]For a general history of accreditation, see Lloyd M. Blauch, ed., *Accreditation in Higher Education* (Washington: U.S. Government Printing Office, 1959.)

[2]National Commission on Accrediting, *List of Recognized Accrediting Agencies* (Washington: The Commission, 1970). The regional associations serve the New England, Middle States, Southern, North Central, Northwest, and Western regions.

TABLE 20.--Historical Development of the Regional Accrediting Associations

Association	Year of Founding	Year College Accreditation Began
New England	1885	1952
Middle States	1889	1921
North Central	1895	1910
Southern	1895	1917
Northwest	1917	1921
Western	1924	1949

intended to stimulate institutional improvement. The six associations vary somewhat in their practices, but all use visiting accreditation teams, require an institutional "self-study" and allow for an "appeals" procedure in case of unfavorable action. Semi-annually, a list of accredited institutions is published. This publication is issued by the Federation of Regional Accrediting Commissions of Higher Education (FRACHE), a body formed in 1964 to coordinate the efforts of the regional associations.

Since the regional associations were among the earliest of the accreditating agencies established and because they historically were concerned with general standards of secondary and higher education, they have assumed the function of accrediting total institutions rather than particular programs of studies. The latter purpose is served by various professional agencies, ECPD for one. Such professional agencies are approved for their activity by the National Commission on Accrediting[1] if an identifiable social need exists for accreditation of the curriculum in question. The professional bodies may participate simultaneously with a regional association in an accreditation visit, or they may act independently. Each agency publishes a list of approved curricula.

Accrediting Activity in Engineering Technology

ECPD operates within the framework of accreditation just described. It has served as the professional agency to accredit engineering programs

[1]The National Commission on Accrediting (NCA) was formed in 1949 by the colleges and universities of the United States in order to coordinate accrediting activities in higher education, for there appeared to be in mid-century undue proliferation of bodies concerned with accreditation. NCA has exerted over the past two decades herculean efforts to bring order to what was, in 1948, a highly confused situation.

since 1932, and has maintained accreditation procedures for engineering technology curricula since 1944.

Interest in the accreditation of engineering technology curricula had developed prior to 1944, as evidenced by this statement in the ECPD *Annual Report* of 1945:

> The movement to recognize technical institute programs was given impetus at a meeting of representatives of a group of institutions offering terminal technical curricula of intermediate type, held in Pittsburgh in 1940. Those present adopted a resolution petitioning the Engineers' Council for Professional Development to inaugurate the program of accrediting which is now being initiated. The intervening period has been spent in studying accrediting procedures, in formulating explicit principles and methods, and in obtaining the approval of the constituent societies which comprise ECPD. These preliminary steps are now completed, and the accrediting program will go into effect the fall of 1945.[1]

An accrediting program did indeed "go into effect", for seven curricula at three schools were listed as accredited the following year, and a permanent "Subcommittee on Technical Institutes" was found.

The original Subcommittee on Technical Institutes has undergone several changes in structure and organization since its original appointment. Initially a subcommittee of ECPD's Committee on Engineering Schools, it later became the Subcommittee on Engineering Technology Curricula of the Council's Education and Accreditation Committee. Subsequent reorganization of the Council resulted, in October 1964, of the establishment of the Subcommittee as a standing committee of ECPD and its designation as the Engineering Technology Committee; at the same time, the name of the parent committee was changed to the Engineering Education and Accreditation Committee.

The Engineering Technology Committee of ECPD normally considers for accreditation only curricula offered in a higher institution which is accredited by the appropriate regional association, but it will also accredit curricula where the regional association either makes no provision for accreditation of specialized institutions or demurs from such accreditation because of the organizational structure of the institution. Curricula only, not institutions, are accredited, and then only at the request of the institution. Both two-year and four-year curricula are eligible for accreditation. A visitation

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[1]W. P. Hammond, Chairman, Subcommittee on Technical Institutes, in Engineers' Council for Professional Development: *Thirteenth Annual Report* (New York: The Council, 1945), p. 14.

team--carefully selected on the basis of curricula to be examined--visits the institution, reviews the curricula, writes a detailed report, and recommends accreditation if the curricula meet established criteria. Accreditation is granted, however, only if a program has graduates who are employed prior to the time of action on the visitation team's report. ECPD also has provisions for recognizing programs with "reasonable assurance of accreditation" (if the programs are in the planning stage) and programs which are "candidates for accreditation" (if the programs are underway but no classes have graduated). No lists of "reasonable assurances" and "candidates" are published, but the institution and the U.S. Office of Education are notified if such status is granted.

Basis for Accrediting Engineering Technology Curricula

The Engineering Technology Committee lists a number of basic qualifications for accreditation of an engineering technology curriculum:

(1) *Duration.* Not less than two academic years of full-time resident academic work beyond the secondary school or the equivalent in part-time resident academic work.

(2) *Requirements for Admission.* High school graduation or equivalent, with a background in mathematics and science.

(3) *Curriculum.* Technological in nature, employing the application of physical sciences and the techniques of mathematics to the solution of technical problems and comprising a prescribed and integrated sequence of related courses in a specific field, though not excluding a reasonable amount of elective appropriate subject matter.

(4) *Instruction.* By accepted class and laboratory methods. Laboratory work shall comprise an important part of each curriculum.

(5) *Teaching Staff.* Qualified as to education and professional technical experience, and sufficient in numbers to provide adequate attention to each student.

(6) *Educational Institution.* An organized school or a division of an institution devoted to the specific aim of providing engineering technology programs; a stable organization having adequate financial support, and demonstrated capacity and achievement in the engineering technology field. The school shall demonstrably maintain a high standard of ethics in its educational program and in all its dealings with students and prospective students. In in correspondence, published material, and other public announcements, the statements used shall be frank and factual and shall not be misleading.

(7) *Physical Facilities*. Adequate for the purposes of the curricula offered.

In the evaluation of engineering technology curricula, ECPD relies on a list of criteria developed as the result of a national study conducted by ASEE, the results of which were published in 1962.[1] ECPD normally finds a two-year curriculum acceptable if it contains approximately one-fourth academic year of mathematics beyond college algebra and trigonometry, one-fourth year of basic science other than mathematics, one-fourth year of non-technical subjects including oral and written communications, at least one year of technical courses, and humanistic-social studies to complete the program. Four-year curricula are currently accredited on the same basis, although criteria are being developed especially for the baccalaureate programs.

Progress in Accreditation

Since 1946, when the first list of accredited curricula was published, there has been an increasing activity both in accreditation of new curricula and re-evaluation of previously accredited curricula. Figure 7 shows the number of accredited curricula by year and its table displays the number of institutions by year having one or more ECPD-accredited curricula. Table 21 gives detailed historical information, listing by name the institutions with ECPD-accredited curricula, and indicating the number of curricula so accredited and the years in which accredited.

The number of students enrolled in institutions having ECPD-accredited curricula is of interest. In the fall of 1969, for example, 23,669 full-time and 5,636 part-time students were reported as enrolled in schools having one or more curricula accredited by ECPD. This compares to a total reported enrollment in engineering technology programs of 110,975 full-time and 34,683 part-time students.[2] Thus, approximately 21 percent of full-time students and 16 percent of part-time students enrolled in engineering technology curricula are attending institutions having one or more such curricula accredited by ECPD.

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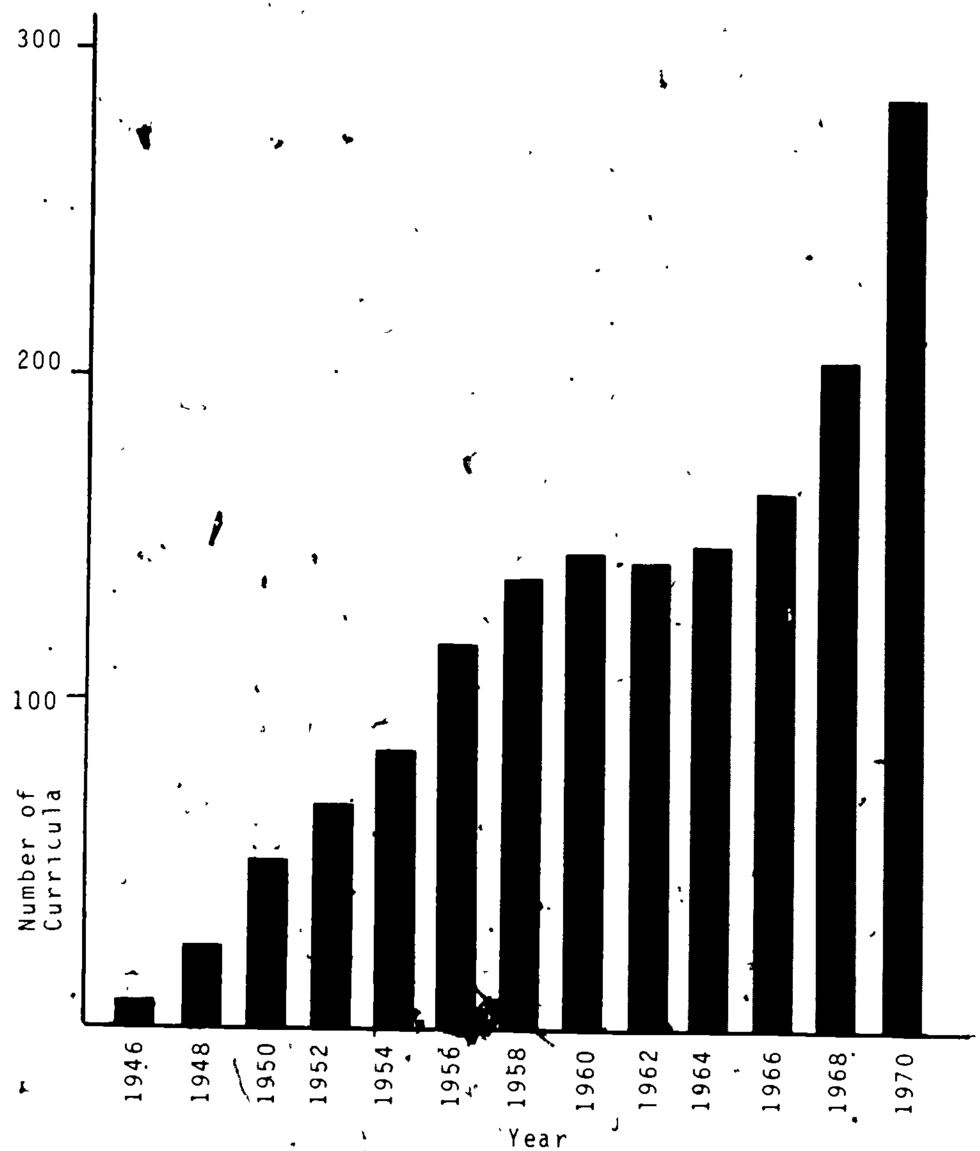
[1] American Society for Engineering Education, *Characteristics of Excellence in Engineering Technology Education* (Urbana, Illinois: The Society, 1962).

[2] John D. Alden, "Engineering and Technician Enrollments, Fall 1969," *Engineering Education*, Sept-Oct., 1970, pp.31-47.

FIGURE 7.--Engineering Technology Curricula Accredited by ECPD, 1946 to Present.



DETAILED DATA--Number of Institutions having One or More ECPD-Accredited Engineering Technology Curricula, 1946 to Present.

Year	Number of Institutions	Number of Curricula
1946	3	7
1947	7	14
1948	13	25
1949	19	53
1950	19	51
1951	22	64
1952	23	69
1953	26	80
1954	28	85
1955	30	91
1956[a]	42	117
1957	45	131
1958	47	137
1959	46	140
1960	46	146
1961	44	140
1962	44	142
1963	43	148
1964	44	148
1965	48	159
1966	49	165
1967	61	196
1968[b]	63	204
1969[c]	68	235
1970[d]	89	283

[a]The basis of reporting accreditation status was changed by ECPD in 1962, so that programs in branch campuses of the same institution were reported separately after that date. It has been possible to correct data from 1956 onward to reflect this policy change.

[b,c,d]Data includes baccalaureate curricula at some institutions.

TABLE 21.--Institutions Having One or More ECPD-Accredited Engineering Technology Curricula and Number of Curricula Accredited, by Year

Institution	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Academy of Aeronautics		4	4	4	4	4	4	6	6	6	6	6	4	4	5	5	5	6	6	3	3	3	3	4	4
Aeronautical University, The		1	1	1	1	1	2	2	1	11	1	1	1												
Akron, University of																							2	2	2
Alfred, SUNY/ATC											4	4	4	4	5	5	5	5	5	6	6	6	6	6	6
Bliss Electrical School	1	1	1	1	1																				
Blue Mountain Community College																									2
Bridgeport Engineering Institute			2	2	2	2	2	2	2	2															
Brigham Young University																						3[a]	3[a]	3[a]	3[a]
Bronx Community College																		2	2	2	2	2	2	2	2
Broome Technical Community College													3	3	3	3	3	4	4	4	4	4	4	4	4
Cal-Aero Technical Institute			1	1	1	1	1	1	1																
Canton, SUNY/ATC					1	1	1	3	3	3	3	3	3	2	2	2	2	4	4	4	4	4	4	4	4
Capitol Institute of Technology[b]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	11	1	1	1	1	2[c]
Central Technical Institute				1	1	1	1	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
Chattanooga State Technical Institute																								4	4
City College of San Francisco												8	8	8	8	8	8	8	8	8	8	5	5	5	5
Cogswell Polytechnical College						2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Dayton, University of									3	3	3	3	3	3	3	3	3	3	3	3	3	3	4[c]	4[c]	4[c]
Del Mar College																									8
DeVry Institute of Technology (Chicago)										1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DeVry Institute of Technology (Phoenix)																									1
Eastern New Mexico University																					2	2	2	2	2
Electronic Technical Institute											1	1	1	1	1										
Embry-Riddle Aeronautical University[d]													1	1	1	1	1	1	1	1	1	1	1	1	2[c]
Erie Community College[e]														5	5	5	5	4	4	4	4	4	4	4	4
Farmingdale, SUNY/ATC																				7	7	7	7	7	7
Fayetteville Technical Institute																						3	3	3	4
Franklin Institute of Boston		1	2	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	5	5	5
Franklin University			2	2	2	1	1	1	1	1	1	1	1	1											
Gaston College[f]																4	4	4	4	4	4	4	4	4	4
Grossmont College																									3
Harford State Technical College											3	3	3	3	3	3	3	3	3	3	3	3	3	5	5
Houston, University of						5	5	5	5	7	7	6	6	6	5	5	5	5	5	6	6	6	6[g]	6[g]	6[g]
Hudson Valley Community College																									7
Iowa State University																		3	3	3	3	4	4	4	4
Indiana Univ.-Purdue Univ./Indianapolis																									3[c]
Institute of Drafting and Technology																									1
Latin Drafting College								2	2	2	3	3	3												
Lake Superior State College																						1	1	2	2
Lowell Technological Institute																								2[c]	2[c]
Michigan Technological University																									2
Midlands Technical Education Center																								5	5
Milwaukee School of Engineering			3	4	4	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	8	8	8	8	12[a]
Mohawk Valley Community College											2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
Nevada, University of																									4
New Hampshire Technical Institute																									3
New York City Community College														4	4	4	4	4	4						
Northeastern Univ. Lincoln College																									2[g]
Northrup Institute of Technology		1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	2
Norwalk State Technical College																				5	5	5	5	6	6
Ohio College of Applied Science[i]			1	1	1	1	2	3	3	3	4	4	[illegible]	4	4	4	4	5	5	5	5	5	6	6	6
Ohio Technical College																		1	1	1	1	1	1	1	1
Oklahoma State University				8	8	8	8	7	7	7	7	7	7	7	7	6	6	6	6	6	6	4	4	4	4
Old Dominion University																									3
Oregon Technical Institute								2	2	2	2	2	3	3	4	4	4	6	6	6	6	6	6	6	14[j]
Pennsylvania State University[k]				3	3	3	3	3	3	3															
PSU, Allentown Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, Altoona Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, Beaver Campus																						2	2	2	2
PSU, Behrend Campus[l]											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, Berks Campus[m]											1	1	1	1	2	2	2	2	2	2	2	2	2	3	3
PSU, Delaware Campus																								1	1

Institution	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
PSU, Dubois Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, Fayette Campus																						2	2	2	2
PSU, Hazelton Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
PSU, McKeesport Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	3	3
PSU, Mont Alto Campus																						2	2	2	2
PSU, New Kensington Campus															2	2	2					2	2	2	2
PSU, Ogontz Campus											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, Schuylkill Campus[n]											1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
PSU, Shenango Valley Campus																						2	2	2	2
PSU, Wilkes-Barre Campus												2	2	2	2	2	3	3	3	3	3	3	3	3	3
PSU, Worthington Scranton Campus[o]											2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
PSU, York Campus											2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
Phoenix College																								1	1
Purdue University				3	3	3	3	3	3	4	4	4	4	4	4									4[a]	4[a]
Queensborough Community College																				1	1	1	1	1	1
RCA Institutes			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1
Ricks College																									1
Rochester Institute of Technology						4	4	4	4	4	4	4	4												
Sacramento City College															1	1	1								
St Petersburg Junior College																			1	1	1	1	2	2	2
Sinclair Community College												2	2	2	2	2	2	1	1	1	1	1	1	1	2
Southern Technical Institute				7	7	7	7	8	8	8	8	8	8	8	8	8	8	9	8	8	8	8	7	10	10
Sparton School of Aeronautics				3	3	3																			
Spring Garden College[p]							2	2	2	2	2	2	2	2	2	2	2			2	2	2	2	2	2
Technical Education Div Philco Corp								1	1	1	1	1													
Temple University, Tech Institute																								2	2
Texas, Univ of at Arlington														4	4	3	4	4	4	4	4	4	4	4	4
Thames Valley State Tech College																						5	5	5	5
Valparaiso Technical Institute						3	3	3	3	3	2	2	2	2	2	1	1								
Vermont Technical College																				1	1	5	5	5	5
Ward School of Electronics												2	2												
Waterbury State Tech College																						5	6	5	5
Weber State College																							1	1	1
Wentworth Institute	4	4	4	4	4	4	5	5	5	5	5	8	10	11	12	12	12	13	13	13	15	15	15	15	15
West Virginia Inst of Tech								1	1	1	1	1		1											

[a] Includes 2 baccalaureate program,

[b] Formerly, Capitol Radio Engineering Institute

[c] Includes 1 baccalaureate program

[d] Formerly, Embry-Riddle Aeronautical Institute

[e] Formerly, Erie County Technical Insitutute

[f] Formerly, Gaston Technical Institute

[g] All baccalaureate programs

[h] Formerly, Richland Technical Education Center

[i] Formerly, Ohio Mechanics Institute

[j] Includes 7 baccalaureate programs

[k] Accreditation originally inc[illegible] all centers, data from 1956 onward have been corrected to show status of individual [illegible]

[l] Formerly, Erie Center

[m] Formerly, Wyomissing Center

[n] Formerly, Pottsville Center

[o] Formerly, Scranton Center

[p] Formerly, Spring Garden Institute

Current Issues

Accreditation of Baccalaureate Programs

A major issue confronting ECPD, one not completely resolved at this time, is that of accrediting baccalaureate engineering technology programs. In anticipation of the problem, ECPD had inaugurated a study of four-year programs in 1964; a committee, chaired by Dean H. E. McCallick of the University of Houston, issued a report in June, 1965. As a result, ECPD revised its statement on Objectives and Procedure to recognize that engineering technology programs "normally lead to the associate or baccalaureate degree." In the meantime, a request for accreditation of a baccalaureate engineering program had been received. Lacking criteria, ECPD postponed action, but charged the McCallick committee to develop guidelines for the evaluation and accreditation of such programs. Simultaneously, another ECPD committee with Dean M. R. Lohmann of Oklahoma State University as Chairman was appointed "to consider in depth the problems presented by the request for accreditation of four-year curricula in engineering technology." The two committees articulated their efforts. ECPD accepted the recommendation that the criteria being used for two-year curricula be applied also to four-year programs. Subsequent to the official action by ECPD's Board of Directors, baccalaureate programs at 12 institutions have been accredited. In addition, in 1970, a set of "Guidelines for Interim Criteria for the Accreditation of Baccalaureate Degree Programs in Engineering Technology" were presented to the ECPD Board of Directors.[1]

A number of problems, however, remain:

(1) Evaluative criteria relating specifically to the baccalaureate program have not been adopted.

(2) The National Commission on Accrediting, although it has recognized ECPD as an auxiliary accrediting agency for matters relating to the associate degree, has not recognized ECPD for accrediting baccalaureate engineering technology programs.

(3) There appears to be considerable uncertainty about the place of the graduate of a four-year engineering technology program in the spectrum of technological occupations; although data

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[1] See ECPD, *op.cit.*, p.16 for a summary of these guidelines.

are being accumulated, there is yet too little experience with the graduates of baccalaureate engineering technology programs to evaluate their competencies or career roles.

(4) Not all of ECPD's constituencies agree that the Engineering Technology Committee should have responsibility for the accreditation of baccalaureate programs.

The accreditation of baccalaureate engineering technology programs by ECPD has many implications for institutions which offer associate degree engineering technology curricula. Among the questions raised, these appear important.

(1) How will accreditation affect transfer opportunities from associate degree programs?

(2) Will the existence of accredited baccalaureate programs compromise the integrity of existing associate degree curricula?

(3) Will enrollments in associate degree programs be changed as a result of the inauguration of baccalaureate programs? (Some institutions have already noted substantial increases in freshman enrollments, and attribute the effect to the availability of a four-year program in a neighboring senior institution.)

(4) What implications for curriculum revision exist at the lower-division level when upper-division programs become accredited?

(5) Will some baccalaureate programs become a source of instructors for associate degree curricula?

(6) Will there be an appreciable change in the educational role of institutions which offer associate degree programs, that is, will they become essentially "transfer" institutions?

The answers to these and similar questions are likely to remain unknown for several years; the resolution of the problems they imply are likely to be a critical issue for a decade or more.

Continued Lack of Interest by Community Colleges

Since 1961, the American Association of Junior Colleges has taken an official stand against the accreditation activities in two-year institutions of all specialized agencies, ECPD included. In January of 1965, a resolution of AAJC instructed their members on the board of the National Commission on Accrediting to "secure NCA initiative and leadership to reconcile and to systematize the diverse elements and organizations in specialized and general accreditation..." NCA has expressed a commitment toward this goal.

The AAJC has two basic concerns about accreditation by specialized agencies; these relate to cost and to the proliferation of accrediting agencies. Regional accreditation, the junior colleges feel, is an adequate assessment of program quality.

A study conducted by the Center for Research and Development in Higher Education, University of California at Berkeley, and supported by the U.S. Office of Education focused on the problem.[1] The study report contained conclusions that the anxiety of two-year colleges about proliferation and cost were largely unfounded, that the problems institutions face with regard to specialized accreditation are largely sociological in nature, that problems related to licensure and legislation are the real concern, and that accreditation is likely to continue as a problem for two-year colleges for the next decade.[2]

In spite of the official stand of the majority of AAJC members, however, some community colleges have sought and achieved accreditation of their engineering technology programs. The current ECPD list contains 15 such institutions having a total of 42 curricula so accredited. It is certain that many other institutions have patterned their engineering technology curricula after those in the colleges with ECPD accredited curricula. As a consequence, a number of programs exist which satisfy ECPD's criteria, even though these programs have not been formally evaluated. Some observers comment that the exemplary role of the schools on the ECPD list, as individual institutions, has been more significant in improving the quality of engineering technology education than has been the formal accrediting procedure.

The dilemma related to accreditation of engineering technology programs in community colleges is likely to remain unresolved for some time.

<u>Evidence of Interest by Bodies other than ECPD</u>

In addition to the interest shown by ECPD, the general domain of technological education has attracted the attention of several other professional bodies. The National Association of Trade and Technical

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[1]Lloyd E. Messersmith and Leland L. Medsker, *Accreditation of Vocational Technical Curricula in Postsecondary Institutions* (Berkeley: Center for Research and Development in Higher Education, 1969).

[2]*Ibid.*, pp.59-75

Schools, the American Vocational Association, the American Technical Education Association and the newly formed National Association for Industrial Technology are examples of the groups which are considering some of the areas which interface with and--in some cases--overlap the areas of concern of ECPD. Between and among these and other bodies, problems of cooperation, coordination and communication are certain to become critical issues for the future.

CHAPTER 6

CHARACTERISTICS OF FACULTY MEMBERS IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

CHAPTER 6

CHARACTERISTICS OF FACULTY MEMBERS IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

This paper is the report of a study of a selected sample of faculty members at institutions which offer associate degree engineering technology curricula. It includes summary information about such characteristics as educational background, teaching experience, industrial experience, participation in professional activities, and scholarly publications; it presents an overview of faculty perceptions about the strengths and weaknesses of the programs in which they teach; and it reports faculty member's attitudes toward the "critical issues" in engineering technology education. Possible differences in faculty characteristics which may be related to the discipline of teaching or the institutional setting are analyzed and discussed.

Procedure

Information for this report was summarized from data supplied by deans or other administrators, from comments written and submitted by faculty members, and from notes made on personal interviews with faculty members at institutions visited for that purpose by the chief investigator. Originally, 24 institutions were visited, and individual or group interviews with more than 150 faculty members were held. Not all 24 participating institutions, however, submitted all the documents which were needed, so that complete data were available from only 17 institutions. Faculty characteristics such as degrees, teaching experience, industrial experience and the like were elicited by means of a "Faculty Profile Data Sheet" completed by an administrator; faculty members were not identified in any way to the chief investigator. Faculty attitudes and perceptions were supplied in the form of written documents submitted by faculty committees at each of the participating institutions; "content analysis" techniques were used by the chief investigator to produce a summary.

Sample

The sample of faculty members includes 404 individuals at 17 institutions; the sample is reasonably distributed by geographic region of the country, by technical specialty, and by institutional setting. The following tables and discussion describe the sample in detail.

Table 22 shows the distribution of the sample by region and by nature of teaching assignment, that is, "technical" or "general" subjects. For purposes here, teaching assignments in English, mathematics, natural science, humanities and social studies were termed general subjects; all others were, therefore, considered technical subjects. The table reveals that 274 of the 404 faculty members in this sample (about 68 percent) were teaching such technical subjects.

TABLE 22.--Distribution of a Sample of 404 Engineering Technology Faculty Members by Region and by Teaching Assignment.

Geographic Region	Number of Individuals, by Assignment		
	General Subjects	Technical Subjects	All Subjects
Northeast	38	91	129
Southeast	45	47	92
North Central	40	67	107
South Central	5	32	37
West	2	37	39
TOTAL	130	274	404

To some extent then, technical faculty appear to be slightly over-represented in the sample, for associate degree engineering technology curricula usually contain only about 55 percent of their credits in the technical areas, (see Chapter 2), so that one might expect to find just 55 percent of the faculty teaching technical subjects. Such an expectation is not entirely justified: it must be kept in mind that class sizes in general subjects are often larger than in technical subjects, so that some skew of the technical/general faculty ratio in the technical direction should be expected; furthermore, technical subjects--especially laboratories--often have special additional faculty manpower requirements, a factor which also tends to skew the faculty ratio. On the other hand, one factor in the research design has produced a real bias: in institutions where the teaching responsibility for general subjects lay outside the control of the engineering technology unit, no data on "general faculty" were collected. This bias, however, is small because only a small number of the participating institutions had such an administrative pattern. In any case, the over-representation in the sample of faculty members teaching technical subjects is not considered serious.

The 404 faculty members in the sample taught in three major institutional settings, defined as follows:

Monotechnical Institutes--single purpose institutions having engineering technology education as their sole institutional objective;

Polytechnical Institutes--institutions with a variety of objectives related to technical and occupational fields, including programs related to business, health and public service as well as to engineering;

Comprehensive Community Colleges--institutions which include an occupational-technical program as well as a liberal arts or pre-professional "university parallel," "transfer" program and an adult education, community service program.

Of the 17 institutions participating in the study, 4 were classifiable as monotechnical institutes, 7 as polytechnical institutes, and 6 as comprehensive community colleges. Both engineering technology enrollments and size of engineering technology faculty, however, were appreciably smaller at the more multipurpose institutions, so that the largest proportion of the faculty members in the sample came from monotechnical institutes. This is indicated in Table 23, which shows the distribution of the sample by institutional setting and by teaching assignment.

TABLE 23. Distribution of a Sample of 404 Engineering Technology Faculty Members by Teaching Assignment and by Institutional Setting

Institutional Setting	Number of Individuals, by Teaching Assignment		
	General Subjects	Technical Subjects	All Subjects
Monotechnical Institution	80	124	204
Polytechnical Institution	39	109	148
Comprehensive Community College	11	41	52
TOTAL	130	274	404

The faculty members in the sample were distributed by discipline as shown in Table 24. Examination of Table 24 reveals that in the sample the largest number of technical faculty members is associated with the electrical/electronics area; the number of individuals related respectively to the mechanical, drafting, and civil areas follow in that order. Other research[1] has shown that the distribution by technical specialty of both students and graduates follow patterns similar to this one; such consistencies support an assumption that the sample of engineering technology faculty members considered here is adequately representative.

TABLE 24.--Teaching Disciplines of a Sample of 404 Engineering Technology Faculty Members

Teaching Discipline	Number of Faculty
Civil Technology	33
Drafting, Drafting Technology	44
Electrical/Electronics Technology	95
Mechanical Technology	59
Other Technology Areas[a]	37
English, Communications	30
Mathematics	40
Physics, Chemistry	35
Humanities/Social Studies	21
Other and no response	10
TOTAL	404

[a]Includes Aeronautical, Air Conditioning, Architectural, Chemical, Computer, Heating, Industrial, Management, Textile, and Environmental

Faculty Characteristics

Rank

While not all the participating institutions conferred academic rank on their faculty members, the majority did. The number of individuals reported in each of the traditional rank categories is shown in Table 25. The category "other" in the table includes titles such as "laboratory instructor," "special lecturer," and the like. The table reveals that, while only a small fraction of engineering technology faculty members carry "full professor" titles, the majority (234 individuals, 58 percent of the total) have "professorial" rank

[1]See, for example, Chapters 7 and 8, herein.

TABLE 25.--Academic Rank of 404 Engineering Technology Faculty members

Academic Rank	Number of Individuals	Percentage of Total
Professor	22	5
Associate Professor	87	22
Assistant Professor	125	31
Instructor	113	28
Other	19	5
Rank not applicable	38	9
TOTAL	404	100

in one of the three grades traditionally used. An appreciably smaller number (132 individuals, 33 percent of the total) are in the "instructor" and "other" grades. If it is assumed that the individuals in the "Rank Not Applicable" category would be distributed proportionately to the five rank categories were rank available to them, then approximately 64 percent of the engineering technology faculty members in this sample would have professorial ranks and 36 percent would have less-than-professorial rank. The inference follows that engineering technology faculty members are predominantly tenured and experienced teachers whose achievements and competencies have received recognition in the form of academic rank or title.

Educational Backgrounds

Collectively, the 404 faculty members in the sample had earned 50 associate degrees, 373 bachelor's degrees, 217 master's degrees and 14 doctor's degrees--a total of 654 such awards; only a small number (3 percent of the sample) reported no degree, and these were most often individuals with special credentials such as an FAA license or a journeyman machinist's rating.

His highest earned degree is usually considered the credential most descriptive of the qualifications of a faculty member. Table 26 summarizes this information for the engineering technology faculty members in this sample. Examination of the table reveals that 93 percent of these individuals hold bachelor's or higher degrees and 55 percent hold master's or higher degrees.

Detailed analysis of the data revealed no statistically significant differences in the distribution of faculty credentials by institutional setting and by teaching assignment were studied. Tables 27 and

TABLE 26.--Highest Degree Credentials Possessed by a Sample of 404 Engineering Technology Faculty Members

Credential	Individuals Possessing Credentials	
	Number	Percentage
Less than Bachelor's Degree[a]	34	8
Bachelor's Degree	149	37
Master's Degree	207	[illegible]2
Doctor's Degree	14	3
TOTAL	404	100

[a]Includes associate degrees, diplomas, and certificates.

TABLE 27.--Distribution by Institutional Setting of Highest Degrees for a Sample of 404 Engineering Technology Faculty Members.

Highest Degree	Percentage of Faculty, by Institutional Setting[a]			
	M	P	C	Total
Less than Bachelor's[b]	10	7	4	8
Bachelor's	35	43	27	37
Master's	51	48	61	52
Doctor's	3	2	8	3

[a]M=monotechnical institutes, P=polytechnic institutes, C=comprehensive community colleges as defined in this paper.

[b]Includes associate degrees, diplomas, and certificates.

28 contain the data. Table 27, for example, displays the distribution by institutional setting of the percentages of faculty members having various highest academic credintials. It is readily apparent from the table that engineering technology faculty members at community colleges more often possessed advanced degrees than did their counterparts at monotechnical or polytechnical institutes. Furthermore, the largest number of faculty members without bachelor's or higher degrees were employed by monotechnical institutes. Table 28 shows data similar to that of Table 27, but includes only faculty members teaching technical subjects, a subset of 274 individuals from the total of 404 in the sample (see Table 23 and accompanying discussion). The data in Table 28 do not reveal any new relationships by institutional setting and

TABLE 28.--Distribution by Institutional Setting of Highest Degrees for 274 Engineering Technology Faculty Members who teach Technical Subjects

Highest Degree	Percentage of Faculty, by Institutional Setting[a]			
	M	P	C	Total
Less than Bachelor's	16	7	5	11
Bachelor's	37	45	32	39
Master's	46	45	56	47
Doctor's	1	3	7	3

[a]See footnotes, Table 27.

lead to the same inferences as just stated. On the other hand, a comparison of the data in the two tables suggests that engineering technology faculty members who teach technical subjects may have fewer advanced degrees than those who teach general subjects; the differences, however, are small.

Agreement of Educational Background with Discipline of Teaching

An investigation was made of how well the educational backgrounds of each of the 404 engineering technology faculty members corresponded to their teaching assignments. "Agreement" was based on direct correspondence of the discipline of the degree and the discipline of teaching. (For example, an individual with a B.S. in civil engineering who was teaching surveying was scored "agree," an individual with a B.S. in physics who was teaching electronics was scored "disagree," and an individual with a history major who was teaching English was scored "disagree.") Table 29 gives the results. As can be noted from the table, a substantial majority of the faculty members were teaching in their major field. Detailed analysis showed that percentage of "agreements" was (1) slightly higher for faculty members teaching technical subjects than for those teaching general subjects, and (2) somewhat lower for faculty members in comprehensive community colleges than in other institutional settings. In each instance, the differences were small, as indicated in Table 30.

Teaching Experience

The 404 faculty members in the sample reported their prior teaching experience. Table 31 gives a summary of the data. The range in the data reported was 0-39 years; the mean was 8.7 years. The data

TABLE 29.--Agreement of Educational Background and Discipline of Teaching of a Sample of 404 Engineering Technology Faculty Members

Condition	Number of Individuals	Percentage
Background and assignment agree	322	80
Background and assignment do not agree	60	15
Data Insufficient for analysis	22	5
TOTAL	404	100

TABLE 30.--Percentages of Background/Assignment Agreements for Engineering Technology Faculty Members of Various Categories

Faculty Category	Percentage of Background/Assignment Agreements
Technical Faculty	
Monotechnical Institutes	84
Polytechnical Institutes	83
Comprehensive Community Colleges	71
Total, All Settings	82
All Faculty	
Monotechnical Institutes	81
Polytechnical Institutes	81
Comprehensive Community Colleges	71
Total, All Settings	80

TABLE 31.--Aggregate Prior Teaching Experience Reported by a Sample of 404 Engineering Technology Faculty Members

Prior Teaching Experience	Number of Individuals
0 - 4 Years	159
5 - 8 Years	102
9 - 12 Years	55
13 - 16 Years	37
17 - 20 Years	18
21 - 25 Years	14
Over 25 Years	19
TOTAL	404

showed nearly identical patterns of teaching experience for all institutional settings and for the nature of the teaching assignment, that is, technical or general studies. That a substantial majority of the faculty members in the sample reported teaching experience of five or more years is consonant with the distribution by academic rank of this group, previously discussed: 61 percent of the sample have five or more years experience; 58 percent are listed in the "professorial" ranks (see Table 25).

Industrial Experience

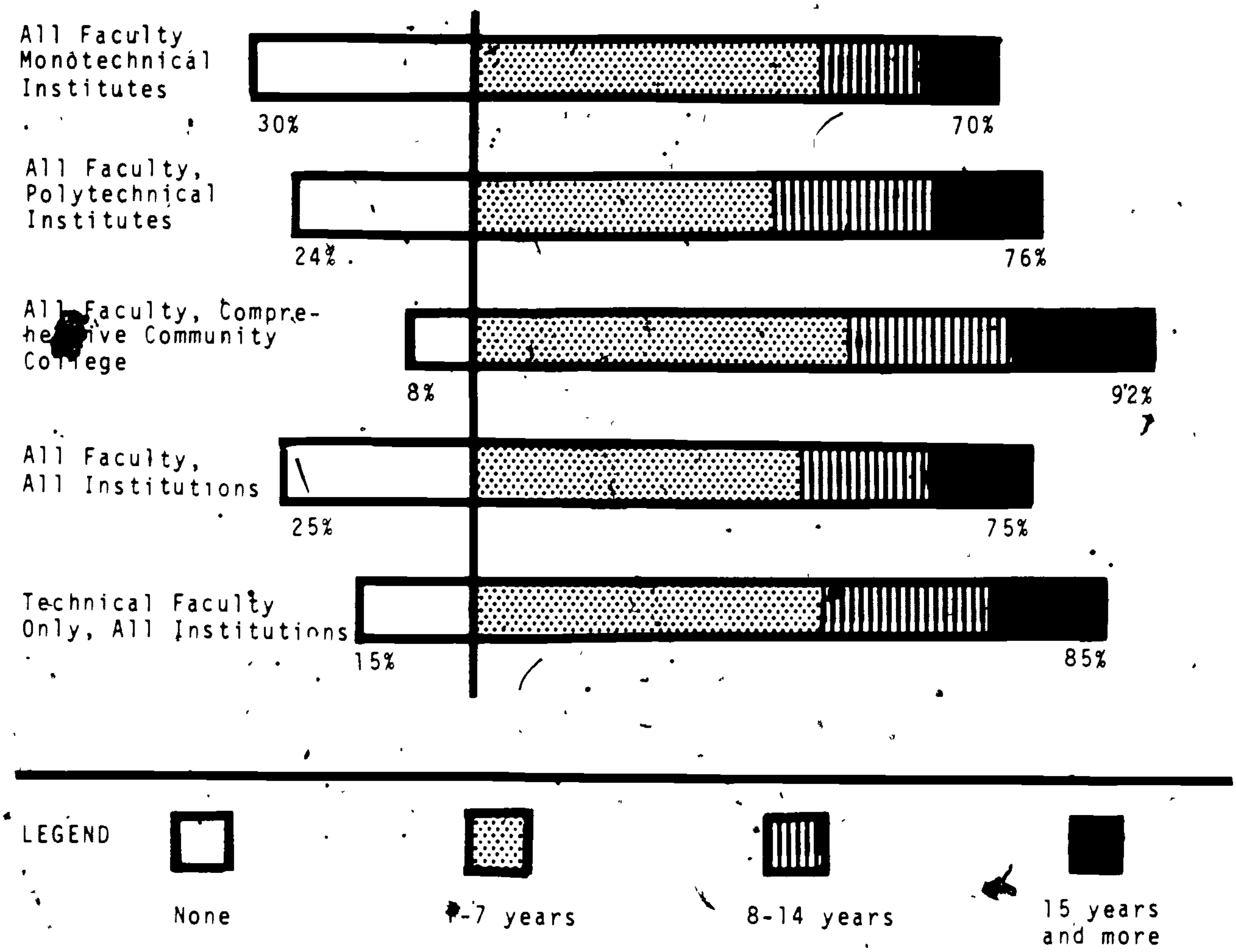
The faculty members in the sample reported the number of years industrial experience they possessed. Table 32 contains summary data. The range reported was 0-43 years; the mean was 6.5 years.

TABLE 32.--Aggregate Industrial Experience Reported by a Sample of 404 Engineering Technology Faculty Members.

Industrial Experience	Number of Individuals
None	98
1 - 4 Years	116
5 - 8 Years	80
9 - 12 Years	44
13 - 16 Years	27
17 - 20 Years	20
21 - 24 Years	7
25 Years or More	12

Detailed analysis of the data revealed only minor difference in the pattern of industrial experience for the faculties of monotechnical institutes, polytechnical institutes and comprehensive community colleges, but showed some differences when technical faculty and total faculty were compared. Figure 8 indicates these results. As might be expected, the proportion of "technical" faculty members with industrial experience is greater than that for the sample as a whole. The interesting finding is that the proportion of "all faculty members, all institutions" without industrial experience (25 percent) is appreciably less than the proportion of faculty members teaching "general" subjects (32 percent); thus, many engineering technology faculty members whose teaching disciplines are mathematics, natural science, English, or humanities/social studies have industrial experience, a condition which some observers would commend highly.

FIGURE 8.--Proportions of Engineering Technology Faculty Members Reporting Various Amounts of Industrial Experience.



Licenses, Professional Registration

The faculty members in the sample reported their possession of a license or professional registration. Table 33 gives a summary of the data. A detailed analysis of the data showed no significant differences in the porportions of license-holders by institutional setting; Table 34 contains the results.

Memberships in Technical and Professional Societies

The 404 engineering technology faculty members in the sample reported their participation in professional activities in terms of memberships in technical or professional societies. For the purposes here, professional societies were defined as organizations principally

TABLE 33.--Licenses Reported by a Sample of 404 Engineering Technology Faculty Members.

Type of License	Number Reported	Percentage of Sample
Professional Engineer	66	16
Registered Land Surveyor	11	3
Engineering Technician[a]	11	3
Other[b]	37	9
TOTAL	125[c]	28[c]

[a]Includes grades of "Engineering Technician" and "Senior Engineering Technician"

[b]Includes Architect, Landscape Architect, Registered Engineer, FCC License, FAA License

[c]12 individuals reported possession of two licenses; thus 113 individuals (28 percent of the sample) possessed one or more licenses.

TABLE 34.--Proportions of Engineering Faculty, by Institutional Setting, with One or More Professional Licenses.

Institutional Setting	Percentage of Faculty with One or More Licenses
Monotechnical Institutes	26
Polytechnical Institutes	30
Comprehensive Community Colleges	31
TOTAL SAMPLE	28

related to the *practice* of the engineering or teaching professions (for example, ASEE, NSPE, state societies of PE's) and technical societies were defined as organizations concerned primarily with one of the *disciplines* of engineering (for example, IEEE, ASME, ASCE). A total of 732 such memberships--professional and technical--were reported, with nearly four-fifths of the individuals in the sample reporting one or more memberships. Table 35 shows the data.

Publications

The faculty members in the sample reported the number of publications credited to them in terms of theses, dissertations, articles

TABLE 35.--Professional and/or Technical Society Memberships Reported by a Sample of 404 Engineering Technology Faculty Members.

Item	Number of Individuals	Percentage of Sample
Individuals with one or more memberships	315	78
Individuals with one or more professional society memberships	243	58
Individuals with one or more technical society memberships	186	46
Individuals with one or more memberships in each type of society	124	31

in scholarly, trade or professional journals, formal papers delivered, texts for which they were the author or a contributing author, and others. A total of 970 publications were reported. Table 36 contains the data.

TABLE 36.--Publications Reported by a Sample of 404 Engineering Technology Faculty Members.

Type of Publication	Number
Theses, dissertations	92
Other Research studies	174
Articles	366
Formal papers delivered	256
Texts	36
Other publications	46
TOTAL	970

Faculty Recruitment

Administrators in the engineering technology units of the participating institutions were asked what strategies they used in the recruitment of faculty members. Most administrators stated that they recruited principally from individuals employed in local industry, and that a major factor in their hiring decision was their personal acquaintance (or that of a staff member) with the individual being recruited. Other strategies were also listed. The recruitment techniques reported are listed in Table 37 in rank order of report frequency.

TABLE 37.--Stategies Used for Recruitment of Engineering Technology Faculty Members, As Reported by Selected Program Administrators.

Recruitment Stategy	Rank Order of Reported Frequency of Use
Recruitment from local industry	1
Advertisement in technical journals	2
Advertisement in newspapers	3
Recruitment from college placement offices	4
Recruitment from teacher placement agencies	5
Recruitment from teachers employed elsewhere	6
Review of "blind" applications	7

Faculty Attitudes

Faculty members in the sample were given opportunities to express their attitudes about their jobs and the curricula in which they were teaching. The comments were of the "free response" type, and have been paraphrased or abstracted in the following paragraphs.

Sources of satisfaction--Faculty members enjoyed "observing students grow...," "being involved directly in the education process...," "getting a job done...," "helping solve the [technical] manpower problem...," and "working with young people..." They liked the "relaxed academic atmosphere" as contrasted with "the pressures of industry." One expressed satisfaction with "...the chance to utilize fully my technical background," and several stated they enjoyed the "challenge" of teaching. The series of comments focused on general satisfaction with the academic environment in which these teachers worked.

Sources of dissatisfaction--Faculty members expressed some concern about "lack of communication on campus," "...interference from 'tradition-bound' [colleagues]...," and the "lack of time to keep abreast of the technical field," but few major dissatisfactions were expressed. Some voiced complaints about "lack of budget for equipment and supplies" or "insufficient funds for operation", but these matters, from the tone of the responses, seemed to be irritations rather than major dissatisfactions.

Perceptions about curriculum--The majority of the faculty members who responded perceived the engineering technology curricula at their institutions as being "excellent" or "strong" in the technical course content. Most identified the "'hands-on' method of instruction" or the "practical approach to problem solving" as a special strength of these curricula. They seemed, however, bothered by factors of "image"; they often expressed a "lack of understanding," or a "lack of acceptance" as unfortunate weaknesses; some deplored the "second-class citizenship" status in which their students reputedly were held. But the most frequently expressed perception was that the engineering technology curricula were not attracting sufficient numbers of qualified students. Positive sentiments, however, predominated in expressions of faculty attitude.

Faculty Assessment of Critical Issues

Engineering technology faculty members were asked to express, in "free response" format, their concepts of the critical issues in engineering technology education. In rank order of frequency of identification, the following problem areas were most often mentioned:

1. Development of public understanding of the nature of engineering technology education.
2. Recruitment of students.
3. Adequate funding for existing and emerging programs.
4. The emergency of the baccalaureate program in engineering technology.

Other issues identified include needs for reduction of attrition rates, articulation with senior institutions, and better feed-back from industry.

Summary

A study was made of 404 engineering technology faculty members, 274 of whom were teaching technical subjects and 130 were teaching general subjects. The individuals in the sample were reasonably distributed by geographic region, institutional setting, and teaching discipline, so that the summary data on the sample adequately provide a profile of engineering technology teachers.

More than 60 percent of such faculty members hold academic ranks of assistant professor or higher; 37 percent are teaching with only a bachelor's degree but 55 percent hold a master's or higher degree.

Only 8 percent have less than a bachelor's degree. These faculty members are usually found teaching in the discipline in which their degrees were earned; this was true in 80 percent of the cases examined.

Engineering technology faculty members have a mean of over 8 years of teaching experience and nearly 7 years of industrial experience. About 28 percent of them hold professional licenses of one sort or another, and 78 percent of them hold membership in professional or technical societies. These individuals also publish scholarly works, the 404 of them having been credited with an aggregate of 970 publications.

Currently, engineering technology faculty members are reported as being recruited most often from individuals employed in industry, although other strategies are also used. These faculty members find satisfaction with the "challenge of teaching," have some concerns about budget for their programs, believe that the "practice-oriented" curriculum is a strength of their program, and identify the "poor public image" of engineering technology as the most critical problem in the area of engineering technology education.

CHAPTER 7

STUDENT TECHNICIANS: A STUDY OF SOME CHARACTERISTICS OF STUDENTS ENROLLED IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

CHAPTER 7

STUDENT TECHNICIANS: A STUDY OF SOME CHARACTERISTICS OF STUDENTS ENROLLED IN ASSOCIATE DEGREE ENGINEERING TECHNOLOGY PROGRAMS

This paper describes briefly some characteristics of students enrolled in selected associate degree engineering technology curricula. It gives some statistical information about their socioeconomic backgrounds, their high school preparation, their motivations and aspirations, and their perceptions of factors which influenced them in making career choices. Data were obtained from questionnaires distributed to students at various institutions which offer associate degree engineering technology curricula.

The Survey

The Questionnaire

The survey instrument used in this study was a questionnaire of 25 items (see Appendix E). A pilot study, based on a 27-item questionnaire, had been conducted; the experience with the pilot, however, showed that two items (numbers 14 and 26 in the original) were redundant and could, therefore be eliminated. The final instrument was printed without renumbering items and with the redundant questions omitted.

Procedure

The questionnaires were distributed to selected students by faculty members or administrators at participating institutions. Students completed the questionnaires anonymously and returned them to their institution. The institution, in turn, submitted the questionnaires to the ETES Staff for analysis. Institutions had been requested to solicit responses from engineering technology students in the second or a later term of the curriculum, but sampling procedures were not specified. Although the sample was not controlled, the general internal consistencies in the data generate some confidence that they are reasonably representative and hence acceptable for the purposes here. Furthermore, the principal investigator interviewed approximately a dozen students at each of the participating institutions and found high degrees of correspondence between information elicited by interview and that obtained from the questionnaire.

The Sample

The survey generated 1241 completed questionnaires from students at 16 different institutions, although not all responses on all questionnaires were usable. Some general characteristics of the sample are summarized below:

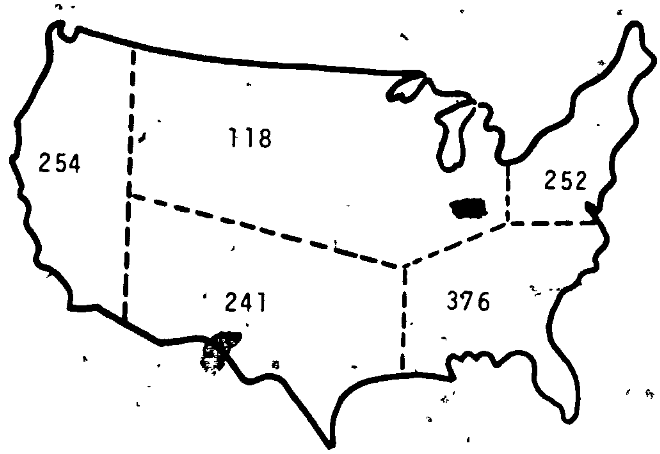
---1212 of the respondents were male, 29 female (women constituted only 2.4 percent of this sample)

---281 (23 percent) of the respondents were married

---92 percent of the respondents were attending college full-time; 8 percent, part-time (it is believed that in the total population of associate degree engineering technology students, part-time students constitute a proportion somewhat greater than 8 percent; hence part-time students may be under-represented in the sample)

---252 were attending colleges located geographically in the northeast region of the United States; 376, in the southeast; 118, in the north central section[1]; 241 in the south central section; and 254 in the west coast region. Figure 9 displays this distribution.

FIGURE 9.--Distribution by Geographic Region of Individuals in a Sample of 1241 Associate Degree Engineering Technology Students.



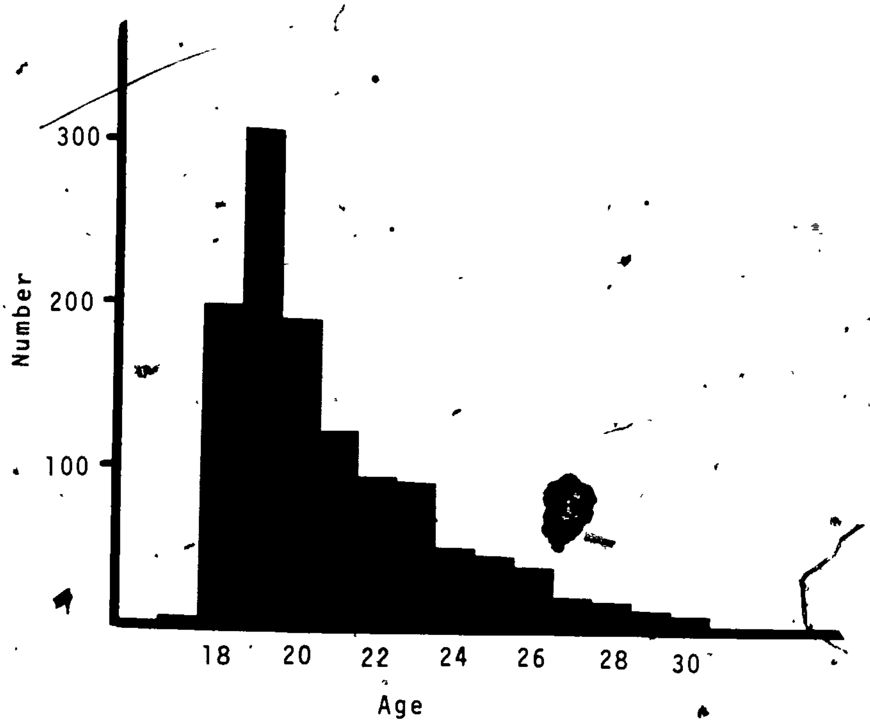
[1]In addition, summary data on 230 additional students in the north central region were available for comparison; however, these data were not included in the analysis here.

Analysis of Data

Socioeconomic Backgrounds

Age--The majority of the associate degree engineering technology students who responded to the survey were 21 years old or younger, 66 percent falling into this category; however, slightly more than 10 percent reported ages of 26 years or more. Figure 10 shows the distribution of ages as reported by 1238 students who responded to Item 1 of the questionnaire. The range of reported ages extended from 17 through 48, with 19 being the most frequently reported age. The accompanying table gives detailed data.

Figure 10.--Age Distribution of 1238 Students in Associate Degree Engineering Technology Curricula.



Age Distribution of 1238 Students in Associate Degree Engineering Technology Curricula.

Age	Number
17	3
18	200
19	305
20	196
21	116
22	95
23	92
24	50
25	44
26	36
27	18
28	17
29	10
30	8
31-35	22
36-40	14
41 & Over	10

Home Location--Table 38 shows the nature of the home locations of those responding to the questionnaire (see Questionnaire Item 22); 1213 individuals supplied data. It is interesting to note that the proportion of engineering technology students coming from farm, rural or small town locations, a total of 31.2 percent, is considerably greater than the corresponding proportion of such individuals in the population as a whole, about 14 percent according to census estimates.

Father's Occupation--The associate degree engineering technology students in this sample appear to come largely from families in which the father is or was associated with a technical field. Of the 1104 students who responded to a question about their fathers' occupations (see Questionnaire Item 24), approximately one-third indicated such a relationship. Table 39 lists, in order of decreasing frequency, the data which were reported.

TABLE 38.--Home Locations of 1213 Students in Associate Degree Engineering Technology Curricula.

Home Location	Students Reporting this Location	
	Number	Percentage
Farm or Rural Area	192	15.8
Small Town	186	15.4
Large Town	93	7.6
Small City	216	17.8
Large City	250	20.6
Major Metropolitan Area	276	22.8

TABLE 39.--Father's Occupation for 1104 Associate Degree Engineering Technology Students.

Occupational Category	Number Reported
Craftsman, skilled worker	156
Technician or equivalent (Construction, operation, repair, inspection, testing, etc.)	133
Supervisor, foreman, manager, executive, etc.	124
Proprietor of business, contractor, etc.	100
Unskilled worker	95
Production worker (skilled)	93
Sales	87
Clerical or office worker	75
Farmer, rancher, etc.	72
Engineer or Scientist	60
Military	45
Physician, Lawyer, Minister, Teacher	37
Miscellaneous (Musician, Policeman, Fireman, Journalist, etc)	28

Family Income--Students in associate degree engineering technology curricula appear to come from families having reasonably adequate incomes, although there was an extended range in the data reported by the 1142 students who responded to a question dealing with this matter (see Questionnaire Item 25). From data reported, the mean family income was estimated to be $790 per month, about $9500 annually. The median income was estimated to be somewhat lower, approximately $8800 per year. Table 40 gives details of the responses made.

TABLE 40.--Monthly Family Income Estimated by 1142 Associate Degree Engineering Technology Students.

Monthly Income	Number of Students
Less than $400	104
$400-$600	298
$600-$800	258
$800-$1000	212
$1000-$1200	102
$1200-$1500	83
Over $1500	85

An interesting and somewhat anomalous pattern was revealed by a detailed examination of the completed questionnaires. Many of the students who reported family incomes of less than $400 per month were individuals who had classed their home locations as a "farm or rural area" and had given their father's occupation as "farmer" or "rancher." Most of these students also reported that their college expenses were coming wholly or mainly from their families. Hence, there are some indications that many who reported low family incomes were reporting "cash flow" data and that "standard of living" or "socioeconomic level" inferences cannot be safely drawn, particularly at the lower levels. Other research data[1] also tend to indicate that the median economic status of the families of technological students is somewhat higher than that of the college population as a whole.

[1]See, for example, American Society for Engineering Education, *The Technician's Peer Groups: A Review of Some Research on High School Students*, Study Report No. 5, Engineering Technology Education Study (Washington, D.C.: ASEE, 1970), pp.13-15.

College Admission and Performance

The vast majority of the students in the sample reported high school graduation or transfer from another college as the basis for admission to college (see Questionnaire Item 11). Only 87 (7 percent of the sample) listed the *General Educational Development Test* as the basis for admission.

The students in the sample reported generally satisfactory performance in their college programs. In response to a question about their current grade point average (see Questionnaire Item 10), 1229 of the 1241 students reported GPA values; the mean of the GPA's reported was 2.46. The distribution was as follows:

Grade Point Average	Number of Students
Lower than 1.5	44
1.5 - 2.4	630
2.5 - 3-4	500
3.5 or higher	55

High School Background

Rank in High School Class--The students in the sample were requested to report their rank in their high school class by quartile (see Questionnaire Item 13). While 24 percent of the students in the sample marked this item as "unknown," the largest number perceived themselves as being in the second highest quartile; the data are given in Table 41. Other research tends to support the findings reported here.[1]

TABLE 41.--Rank in High School Class as Perceived by 1241 Associate Degree Engineering Technology Students.

Rank in High School Class	Students Reporting Rank	
	Number	Percentage
Highest Quarter	277	22
Second Quarter	388	31
Third Quarter	235	19
Lowest Quarter	46	4
Unknown	295	24

[1] *Ibid.*

High School Curriculum--The students in the sample were requested to report the number of years of study they had devoted to selected subject areas in high school (see Questionnaire Item 12). Table 42 summarizes the responses.

It is interesting that all students reported some mathematics study in high school. The level of such high school mathematics was not investigated but, presumably, the first year represented a "general Mathematics" course, the second an "introduction to Algebra." Moreover, 80 percent of the students reported three, four, or more

TABLE 42.--Study of High School Subjects as Reported by 1241 Associate Degree Engineering Technology Students.

Subject Area	Number of Years	Number of Students		
Mathematics	1	60		
	2	184		
	3	367		
	4 or more	630		
			1241	(100%)
Physics	1	590		
	2 or more	51		
			641	(52%)
Chemistry	1	720		
	2 or more	44		
			764	(61%)
Drafting	1	377		
	2	165		
	3 or more	150		
			692	(56%)
Industrial Arts	1	251		
	2	145		
	3 or more	160		
			556	(45%)
Vocational Education	1	126		
	2 or more	192		
			318	(26%)
Technical Education	1	88		
	2 or more	117		
			205	(16%)

years of high school mathematics. Apparently, many of the respondents interpreted this question to include the junior high school years, grades 7-9, since just over 50 percent reported four or more years of study in the area.

Slightly more than half of the students in the sample reported having studied Physics; more than three-fifths reported having studied Chemistry. A close examination of the responses revealed that 495 students reported study of both Physics and Chemistry, 146 reported Physics only, and 269 reported Chemistry only. Thus, 910 students in the sample (73 percent) reported high school experience in a physical science.

High school courses in drafting were reported with appreciable frequency; 692 students (56 percent of the sample) claimed study in this area, and nearly half of these reported more than one year of such study. Courses in industrial arts, vocational education, and technical education were reported less frequently, involving 45 percent, 26 percent, and 16 percent of the sample, respectively. Most frequently, the students who reported drafting experience also reported study of these last areas. Few who had studied both physics and chemistry had also studied industrial arts, vocational education, or technical education subjects.

Curriculum Choice and Changes

Distribution by Specialty--Table 43 lists the distribution by technical specialty or "major" of the students included in the sample (see Questionnaire Item 7). The most popular specialties appear to

TABLE 43.--Distribution by Technical Specialty of 1241 Students Enrolled in Associate Degree Engineering Technology Curricula.

Technical Specialty Area	Number of Students
Electronics	401
Mechanical	197
Civil	177
Drafting	149
Electrical Power	67
Architectural	54
Industrial Engineering	49
Chemical	19
Aeronautical	17
Other	111

be Electronics Technology, Mechanical Technology, and Civil Technology. These three curricula account for a total of 775 of the 1241 students in the sample, or 62 percent of the group surveyed. In the table, the titles for technical specialty areas are arbitrary descriptive terms, not necessarily exact curriculum titles; for example, all students reporting their majors as "Civil Technology", "Civil Engineering Technology", "Highway Technology", "Surveying and Mapping Technology", or the like have been included here in the classification "Civil". The category "other" includes miscellaneous programs of small reported frequency, such as "Textile Engineering Technology", "Air Conditioning Technology", "Electro-mechanical Technology", "Instrumentation", and the like.

Transfer--Approximately 21 percent of this sample of engineering technology students had transfered to the institution they were attending ~~from another~~ college (see Questionnaire Item 6); 266 reported having attended at least one other college and 36 reported having attended two or more other institutions.

Changes of Major--Students in the sample reported changes of major with appreciable frequency (see Questionnaire Item 8); 341 (25 percent of the sample) reported one or more changes of major and 39 reported two or more such changes. Table 44 lists the "previous majors" that were reported by the students responding to this item on the questionnaire; the total number of previous majors reported (371 in the table) exceeds the number of students who had changed majors (341) because those who reported more than one change in major usually reported previous majors in two or more areas.

TABLE 44.--Previous Majors Reported by Certain Associate Degree Engineering Technology Students who had Changed Majors.

Previous Major	Frequency of Report
Engineering	134
Physical Science or Mathematics	28
Another Engineering Technology	69
Liberal Arts	38
Business	42
Vocational Education	15
Education	11
Other[a]	34

[a]Other includes Fine Arts, Agriculture, Health, Forestry, etc.

Students who had changed majors were asked to give the reason for the change (see Questionnaire Item 9); 289 (nearly 85% of those who reported changes) responded to this item on the questionnaire. Their responses are summarized in Table 45. The entries in the table are mainly paraphrases of the actual responses. A pattern seemed to emerge, however, in which changes in major are related principally to students' reassessments of their interests and abilities.

A special analysis was made of the reasons for change given by students who had changed from a major in engineering, physical science or mathematics to one in engineering technology. The 162 students (see Table 44) in this category often stated that they preferred the practical to the theoretical, had lost interest in theoretical courses, or felt they could not cope academically with theoretical courses; two-thirds of the responses given by such students were of this nature. Table 46 contains relevant data.

TABLE 45.--Reasons for Changes in Major Reported by Certain Associate Degree Engineering Technology Students.

Reason for Change	Number Reporting Reason
a. Preference for technical (practical) over engineering (theoretical) program	20
b. Loss of interest in previous choice (e.g., it was boring, it was not what I expected)	102
c. Change in career objective	38
d. Reassessment of ability (e.g., poor academic performance in first choice)	54
e. To enhance spectrum of competencies (e.g., to obtain a second degree, to have a double major)	11
f. Higher pay anticipated in new area	12
g. Economic reasons (e.g., could not afford a longer curriculum)	15
h. Pressures of time (e.g., wanted to finish college as quickly as possible)	13
i. Changed schools, previous major no longer available	9
j. Work experience influenced change	9

TABLE 46.--Reasons Reported by Certain Students for a Change in Major from Engineering, Mathematics or Physical Science to Engineering Technology.

Reason for Change	Number Reporting Change
Preference for Practical Program to a Theoretical One	20
Loss of Interest in Previous Choice	30
Previous Choice Too Rigorous or Too Difficult	31
Change in Career Objective	12
Wanted to Finish College in a Short Time	10
Other	20

College Choice--The students in the sample were requested to list factors which influenced their choice of institution (see Questionnaire Item 20). The questionnaire item eliciting this information was the "free response" type, so that most students gave several factors. The most frequently given factors are summarized in Table 47; "frequency"

TABLE 47.--Factors Purported to Have Influenced Associate Degree Engineering Technology Students in Their Selection of a College.

Factor	Frequency
Location of institution	783
Costs (tuition, fees, expenses)	529
Reputation of institution	408
Recommendations of friends or relatives	254
Institution offered the program desired	97
Recommendations of high school counselor	17
Only institution allowing entry	16

in the table is the total number of times each factor (or its equivalent) was mentioned. In addition to those in the table, a number of other factors were mentioned, but at frequencies too low (fewer than 10) to be meaningful; among these were responses such as "I was sent by my employer", "I was given a scholarship there", "Because the school was accredited", and the like.

Career and Curriculum Choice--The students in the sample were queried on various topics related to their career choice and hence presumably to the curriculum choice they had made (see Questionnaire Items 16-19. Table 48 summarizes students' responses to a question about their ultimate career objective as they now perceived it. As can be noted from the table, the majority listed technical employment or professional employment as their ultimate goal.

TABLE 48.--Career Objectives Reported by 1241 Associate Degree, Engineering Technology Students.

Career Objective	Students Reporting Objective	
	Number	Percentage
Technical employment	734	59
Professional employment	187	15
Management	84	7
Operate my own business	83	7
Teaching	36	3
Employment not related to education	14	1
Research	13	1
Sales	9	1
Undecided (or no response)	81	6

In response to a question about their confidence in the stability of their career choices, these individuals replied as follows:

326 (26 percent) were "positive" about their choice.

600 (48 percent) were "reasonably certain" about it.

142 (11 percent) were "moderately certain" about it.

124 (10 percent) were "not sure" and indicated that this was a tentative choice only.

49 (4 percent) did not respond.

Observations which reasonably follow from these analyses of career objective and stability of career choice are as follows: (1) associate degree engineering technology students appear in substantial numbers to have matched their personal career objectives well with available educational preparatory programs; and (2) these students, in general, appear confident and purposeful in the pursuit of their career goals.

In response to a question related to the time at which their career (and hence curriculum) choice was made, these students reported as shown in Table 49. It is noteworthy that nearly one-half reported having made a career choice in high school.

TABLE 49.--Time of Career Decision as Reported by Certain Associate Degree Engineering Technology Students.

Approximate Time of Career Decision	Students Reporting	
	Number	Percentage
Prior to junior High School	51	4
In Junior High School	37	3
In Senior High School	594	48
After High School Graduation and Working for a Period	171	14
In College	180	14
In Military Service	99	8
No Response	109	9

When asked to identify factors which they perceived to have influenced their career decision, these individuals replied as follows:

707 Listed "personal interest"

318 Listed "work experience"

160 Listed "family influence"

99 Listed "influence of friends"

90 Listed "influence of a high school counselor or teacher"

30 Listed "influence of a professional or college counselor"

51 Listed various miscellaneous factors such as "subject matter taken in high school," "possibility of a good job," etc.

Many listed a combination of several factors; some did not respond to this questionnaire item. Included in the "personal interest" category are such specific comments as "I've always liked to draw," "Radio is my hobby," "Machinery interests me," and the like. Military experience is included, where relevant, under "work experience".

Immediate Post-Graduation Plans

The students in the sample were asked about their immediate plans after completion of the program in which they were enrolled (see Questionnaire Item 15). Table 50 lists the responses and their frequencies.

A special analysis was made of those who stated they planned to continue schooling. Of the 399 who made this statement, 387 supplied additional data; those data are displayed in Table 51. The table reveals that the largest proportion of students planning immediate further schooling after receipt of their associate degrees were planning to pursue baccalaureate degrees in engineering technology; one-half of these students projected such plans; approximately one-fourth of the group indicated a planned engineering program; the remaining one-fourth projected such disciplines as business administration, education, physical science, and industrial management. A pattern of some importance was suggested by the data and was

TABLE 50.--Immediate Post-Graduation Plans Projected by Certain Associate Degree Engineering Technology Students.

Post-Graduation Plans	Students Stating Plan	
	Number	Percentage[c]
To seek employment[a]	671	54
To continue schooling	399	32
To enter military service	93	7
Other[b]	52	4
No response	26	2

[a]Includes continuation of present employment for some who were already employed.

[b]Includes employment on full-time basis for some who are now employed part-time or are attending school under a cooperative program; also includes some who expect to begin a private business.

[c]Does not add to 100% because of rounding.

TABLE 51.--Further Schooling Plans of Certain Associate Degree Engineering Technology Students Who Project Plans for Additional Education Immediately After Receipt of Their Associate Degrees.

Projected Future Major	Number of Students Planning Future Study in Various Environments			
	Same Institution	Different Institution, Same State	Out-Of-State Institutions and no response	Total
Engineering	18	60	20	98
Engineering Technology	17	144	33	194
Other	11	34	50	95
TOTALS	46	238	103	387

strongly supported by reference to individual questionnaires; the in-state existence of an institution offering baccalaureate engineering technology programs greatly influences the tendency of associate degree engineering technology students to pursue further education. A substantial number of the students who stated plans to pursue a baccalaureate degree in engineering technology were students in states where such programs had been recently inaugurated; no such generalization was possible for students planning further study in engineering or other disciplines.

Student Satisfaction with Programs

Students in the sample were requested to express an opinion on how well they felt their programs of study were providing preparation for their chosen careers (see Questionnaire Item 21). The responses were predominantly positive: 38 percent of the students felt they were being "excellently" prepared; 55 percent felt they were being "adequately" prepared; 4 percent felt they were being "inadequately" prepared; and 3 percent did not respond. The data are shown in Table 52. Approximately 93 percent of the sample expressed satisfaction with their educational experience. In addition, more than one-fifth of the students added "free response" comments in their evaluation of their programs. The most frequent positive comments were that "the curriculum is excellent" (49 made this or a similar

TABLE 52.-- Student's Perception of How Well their Associate Degree Engineering Technology Programs were Preparing them for Intended Careers.

Rating of Program	Frequency of Response	
	Number	Percentage
Excellent	467	38
Adequate	681	55
Inadequate	53	4
No Response	40	3

statement) or that "the faculty members are excellently qualified" (27 made a statement of this nature); 88 positive comments were made. On the other hand, a variety of weaknesses were perceived by the 182 students who made negative comments. Most frequently, a specific curriculum area was criticized: "the physics course is weak", "there is not enough coverage in mathematics", and "the statics course did not prepare me for 'strength'" were typical comments. The second most common criticism was a "lack of practical emphasis" in one or more curricular areas. Some students also registered dissatisfaction with "irrelevant subjects" and "insufficient detail in certain areas." A number of others expressed the opinion that their programs were "too crowded" or "too fast in pace"; others suggested that "two years are not long enough to cover what I think I need." Miscellaneous comments on faculty members, laboratory equipment and facilities appeared to a minor extent.

Desired Work Environments

Students in the sample were asked to express a preference for the type of environment in which they would work if they had a choice (see Questionnaire Item 23). These "preferred future environments" were compared with the "environment of origin", ascertained as part of the socioeconomic data on these students (see Questionnaire Item 22 and the earlier discussion herein); 1116 cases could be analyzed with the following results:

441 students had come from a relatively "small" home environment (a farm or rural area, a small town, a large town).

675 students had come from a relatively "large" home environment (a small city, a large city, a major metropolitan area).

252 (57 percent) of those originating in "small" environments would prefer a "small" work environment.

189 (43 percent) of those originating in a "small" environment would prefer a "large" work environment.

541 (80 percent) of those originating in a "large" environment would prefer a "large" work environment.

134 (20 percent) of those originating in a "large" environment would prefer a "small" work environment.

If a "migration by preference" were to occur, than 730 students in this group of 1116 would be working in a "large" environment and only 386 would be working in a "small" environment. Such a migration would represent a shift from low-density to high-density population centers of approximately 5 percent of all technically educated individuals. Although both the number of individuals involved and the percentage of population so shifting seem small, the value is statistically significant well beyond the .001 confidence level, and indicates strongly that *technical education is a route toward urbanization of the population.* This is not an unexpected trend, but is, nevertheless, one with perhaps serious implications.

Summary

If it is assumed that the sample of 1241 associate degree engineering technology students included in this study is representative of the population nationally of such individuals, then certain generalizations can be stated. These generalizations are given in the following paragraphs.

Students in associate degree engineering technology curricula are typically males who are 19-21 years old, although an appreciable number of older students enroll in such curricula.

Individuals from rural areas and small towns often select engineering technology programs; the proportion of engineering technology students with such backgrounds is appreciably greater than their representation in the population as a whole. Engineering technology students are more likely to come from families with monthly incomes above the national mean, and are likely to have fathers who were craftsmen, skilled workers, technicians, supervisors or foremen or in some manner related to technical fields.

The engineering technology student most probably graduated from high school, but is likely to have ranked academically in the second or third quarter of his class. He is likely to have had four or more years of high school mathematics and there are three chances in four that he had a physical science (chemistry or physics or both) in high school. There is about a 50 percent chance that he has studied drafting in high school, but he is less likely to have encountered industrial arts or vocational-technical subjects.

In a class of engineering technology students, one in five will have transfered from another college and one in four will have changed his major. (Those transfering and those changing major are often groups duplicating each other to a great extent.) Most likely, the previous selection of those who have changed major was engineering, and the reason for the change is likely to be stated as a "change in interest" or a "reassessment of academic ability."

The engineering technology student probably made his choice of college on the basis of the institution's location and costs, although the reputation of the school had some influence. He is apt to be "reasonably certain" that he wants eventually to enter technical employment, but he is likely to have made such a career decision fairly late, either in senior high school or after working for a period. His personal interests and work experience were major factors influencing his choice.

Engineering technology students most frequently plan to seek employment after receiving their associate degrees, but nearly one-third plan to continue schooling, usually to work toward a baccalaureate degree in engineering technology. There are some indications that the availability within the state of a baccalaureate technology program is related to students' plans to pursue further education.

Students are satisfied with the preparation they are receiving, although they may perceive minor weaknesses.

Engineering technology education appears to result in urbanization of the society, since students in general express a preference to work in an environment with a greater population density than that from which they came.

CHAPTER 8

ENGINEERING TECHNICIANS ON THE JOB
A STUDY OF ASSOCIATE
DEGREE GRADUATES

CHAPTER 8

ENGINEERING TECHNICIANS ON THE JOB: A STUDY OF ASSOCIATE DEGREE GRADUATES

This paper is the report of a study of a selected sample of recent graduates from associate degree engineering technology curricula. It includes analyses of the job titles and salaries associated with the first jobs which the graduates accepted; it summarizes some data dealing with factors which influenced these graduates in their original college and career decision; and it describes the employment of these graduates in terms of the frequency of performance of certain tasks. Where differences in employment characteristics--by technical specialty and by geographic region--are identifiable, such differences are discussed.

Procedure and Sample

A questionnaire (see Appendix F) was used to elicit data for this study of the recent graduates of associate degree engineering technology curricula. The chief investigator had selected and visited certain institutions which offer such curricula to seek participation in the study. These institutions were requested to select a representative sample of their graduates of the past 18 months, mail a questionnaire and a return envelope to each member of the sample, receive the completed and returned questionnaires, and forward the completed questionnaires to the chief investigator. Individuals were not identified on the completed questionnaires, but some of the participating institutions developed follow-up procedures to enhance the return of instruments from their graduates. Summary and analysis were the responsibility of the chief investigator; however, some institutions extracted data for their own use before forwarding the instruments and others supplemented the questionnaire with additional items.

Originally, 24 institutions were requested to participate in the study. Two of these, however, lacked graduates, having only recently inaugurated engineering technology programs; one lacked a file of addresses of its graduates; and three were not able to participate for other reasons. Two institutions submitted recent data which were comparable to that being requested but which were formatted differently. Ultimately, sixteen institutions participated.

More than 700 questionnaires were returned, but not all were usable; rejections occurred if the respondent was in school or the military service, or if his employment could not be classed "first job or first 18 months," the category selected for study. Only 412 questionnaires were finally included.

Since the sampling procedure was developed by the participating institutions, no direct information related to the representativeness of the sample is available. Certain indirect evidence, however, supports an assumption that the sample reasonably represents the population being studied.

First, the distribution by geographic region for these graduates is similar to that found for students in a previous study.[1] Table 53 shows these relationships; it can be noted in the table that the "Percent of Total" columns for Students and Graduates differ by no more than three percentage points.

TABLE 53.--Comparison of Distribution by Geographic Region of a Sample of 1241 Students and a Sample of 412 Graduates, Associate Degree Programs in Engineering Technology.

Geographic Region	Students		Graduates	
	Number	Percentage of Total	Number	Percentage of Total
Northeast	252	20	75	18
Southeast	375	30	130	32
North Central	118	10	51	12
South Central	241	20	69	17
West	254	20	87	21
TOTAL	1,241		412	

Second, the distribution by technical specialty of the graduates in this sample does not differ markedly from that nationally. Table 54 displays the data. The table indicates that graduates in Civil Engineering Technology are somewhat over-represented in this

[1]See Chapter 7, herein, and Jesse J. Defore, "Characteristics of Engineering Technology Students," *Engineering Education,* April, 1971, pp.844-46.

TABLE 54.--Comparison of Distribution by Technical Specialty of a Sample of 412 Graduates and a National Sample of 18,808 Graduates, Engineering Technology Curricula.

Technical Specialty	Degrees Granted, 1969[a]		Graduates in Sample	
	Number	Percent of Total	Number	Percent of Total
Civil	1,747	9	64	15
Electrical	8,251	44	139	34
Mechanical	3,315	18	91	22
Other	5,495	29	118	29
TOTAL	18,808		412	

[a]Data from John D. Alden, "Technology Degrees, 1968-69," *Engineering Education*, January, 1970; see Table 2, p.411.

sample while graduates in Electrical Engineering Technology (including Electronics) are somewhat under-represented. This bias is not unexpected: many electrical/electronics graduates nationally come from institutions which offer this specialty only; no institution participating in the study was of this type, hence, the research design itself tended to diminish the proportion of electrical/electronics graduates available for study. This minor under-representation is not believed to affect results seriously.

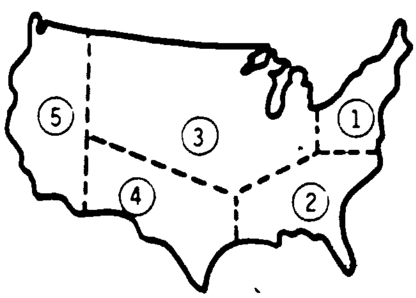
And third, certain detailed findings related to salaries (to be discussed in a later section of this chapter) correspond closely with results of an independent survey conducted recently by the Engineering Manpower Commission

Analysis of Results

The responses to items on the questionnaire are reported and analyzed in the following sections of this report.

In the analysis of the data, summary statistics were computed to describe the characteristics of these graduates and their employment. In addition, the data were examined for internal variances which might be attributable to either (1) the geographic region in which the participating institution was located, or (2) the technical specialty of the curriculum the graduate had completed. For convenience, five geographic regions were arbitrarily selected: Northeast, Southeast, North Central, South Central, and West. These are indicated roughly on Figure 11. A preliminary investigation revealed that 15 different technical specialties were reported by the respondents, but that three--electrical/electronics, mechanical, civil--accounted for more than two-thirds of the sample. Other technical specialties (drafting and design, chemical technology, air conditioning technology, aeronautical technology, computer technology, and the like) appeared with individual frequencies too small for meaningful analysis, so were combined into a single category, "other." Therefore, four technical specialties only were employed. Data on the Graduates were appropriately assigned to twenty cells (five "region" categories, four "technical specialty" categories) for analysis purposes. Figure 12 shows the resulting "N-matrix," i.e., number of graduates assigned to the various cells. The analyses in subsequent sections are based on this matrix, with adjustments for non-respondents when necessary.

FIGURE 11.--Geographic Regions Selected for Study of a Sample of 412 Graduates of Associate Degree Engineering Technology Programs



Region

1 Northeast
2 Southeast
3 North Central
4 South Central
5 West

FIGURE 12.--Distribution by Region and by Technical Specialty of a Sample of 412 Graduates of Associate Degree Engineering Technology Programs.

Technical Specialty	Region					
	1	2	3	4	5	U.S.
Civil	2	41	-	[illegible]	[illegible]	64
Electrical	24	33	13	38	31	139
Mechanical	16	32	12	14	17	91
Other	33	24	26	13	22	118
TOTAL	75	130	51	69	87	412

Job Title

Item 1 of the questionnaire elicited the job title currently held by the graduates; 378 of the 412 respondents reported this information. The term "technician," with or without a modifier, appeared most often. Table 55 gives a summary of the results, and Table 56 lists some examples of specific titles in various categories. The numbers in parentheses in the body of Table 56 represent the frequency with which a specific title appeared in the data considered here.

In addition to the examples listed in Table 56, graduates reported a wide variety of other job titles, including the following: hydrological technician, quality control technician, technical illustrator, equipment designer, traffic engineer, resident engineer, safety engineer, testing analyst, toolmaker, estimator, teacher, surveyor, metallurgical investigator, and programmer.

Few inferences can be drawn from these results. That 62 job titles out of 378 (about 16 percent of this sample) included the term "engineer" may be disturbing to some, but employers apparently do not necessarily assign job titles which match the educational backgrounds of their employees as perceived by educators.

TABLE 55.--Job Titles Reported by 378 Graduates of Associate Degree Engineering Technology Programs.

Category	Number of Graduates	Key Word in Job Title
A	108	Technician
B	70	Aide, Assistant, Associate
C	62	Engineer
D	46	Draftsman
E	19	Mechanic, Electrician, etc.
F	18	Manager, Supervisor, etc.
G	14	Designer
H	9	Analyst
I	3	Technologist
J	29	Other
TOTAL	378	

TABLE 56.--Example of Job Titles Held by Graduates of Associate Degree Engineering Technology Programs.

A. *Technician*

- Engineering Technician (27)
- Electronics Technician (28)
- Civil Technician (5)
- Instrument Technician (5)
- Laboratory Technician (5)
- Technician (6)

B. *Aide, Assistant, Associate*

- Engineering Associate (18)
- Engineering Aide (15)
- Engineering Assistant (9)
- Associate Engineer (5)
- Assistant Engineer (7)
- Staff Assistant (4)

C. *Engineer*

- Project Engineer (12)
- Field Engineer (9)
- Sales Engineer (8)
- Customer Engineer (3)
- Junior Engineer (3)

D. *Draftsman*

- Draftsman (19)
- Design Draftsman (8)
- Senior Draftsman (2)
- Architectural Draftsman (2)

E. *Mechanic, Electrician, etc.*

- Mechanic (4)
- Aircraft Mechanic (3)
- Electrician (6)
- Maintenance Mechanic (1)

F. *Manager, Supervisor, etc.*

- Project Manager (2)
- Service Manager (3)
- Construction Supervisor (1)
- Operations Supervisor (1)
- Foreman (3)
- Plant Superintendent (1)

Mean Salary

Graduates were requested to report their monthly salaries (questionnaire items 6 and 7). Of the 412 graduates in the sample, 409 reported data. Figure 13 shows the distribution of data as reported. The mean salary was estimated to be $688 per month for graduates who were in their first job or had been working for 18 months or less.

An effort was made to discover if differences existed, by geographic region or by technical specialty, in the salaries paid to associate degree engineering technology graduates. Table 57 shows the salary data for this sample. There are few statistically significant differences in these reported salaries, for the difference must exceed $35 to be significant here at the .05 confidence level. Those cells which do exhibit statistically significant differences are marked with an asterisk. The cells which have the

FIGURE 13.--Distribution of Salaries Reported by 409 Graduates of Associate Degree Engineering Technology Programs.

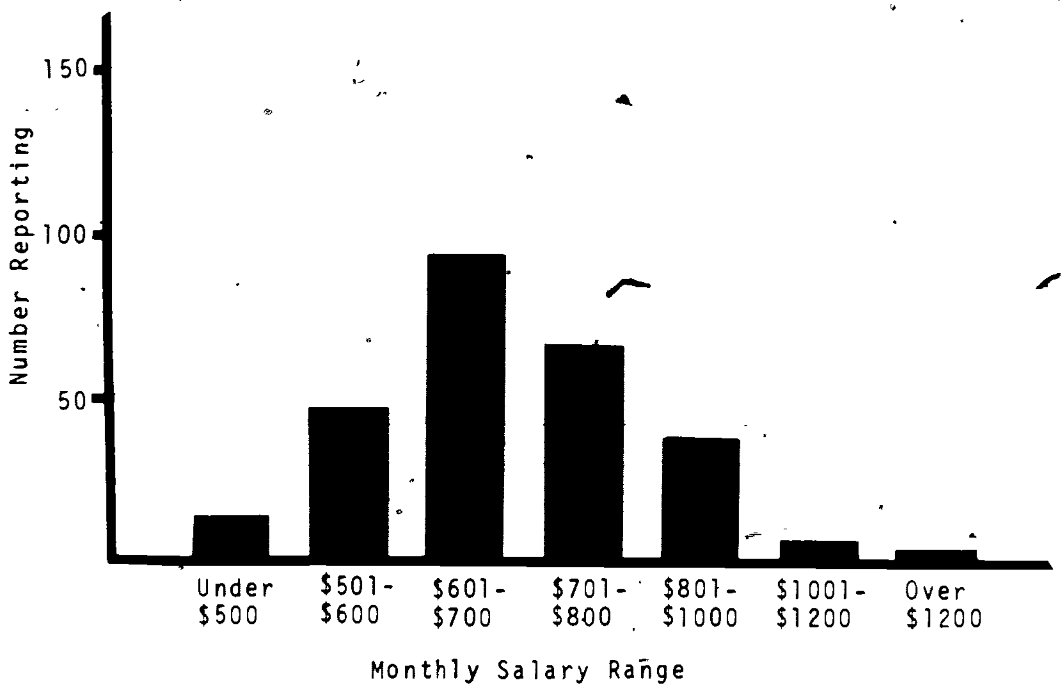


TABLE 57.--Monthly Salaries Reported by 409 Graduates of Associate Degree Engineering Technology Programs, by Technical Specialty and by Region.

Technical Specialty	Region 1	2	3	4	5	US
Civil	525*	642*	-	788*	646	665
Electrical	694	720	770*	714	690	706
Mechanical	721	677	770*	692	666	696
Other	670	686	678	705	625*	672
TOTAL	676	686	723*	712	657	688

greatest deviation from the data mean are those of low N (see figure 12); in these cases, sampling error alone could account for most of the variation.

Although they are relatively small, certain of the variances among these salary data suggest questions.

(1) Salaries in the western region appear slightly lower than elsewhere. Can this be a reflection of the large number

of junior colleges on the west coast and a concommitant larger "supply" of technical manpower there?

(2) Civil technicians appear to command slightly lower salaries (except in the South Central region). Does this reflect the pay scales of state highway departments, often the civil technician's first employer?

(3) Salaries in the North Central region appear somewhat higher than in other areas. Does this represent high manpower "demand," occasioned by a paucity of technical programs in that region? Or is this slightly higher salary a reflection of the general economic and industrial conditions in this region?

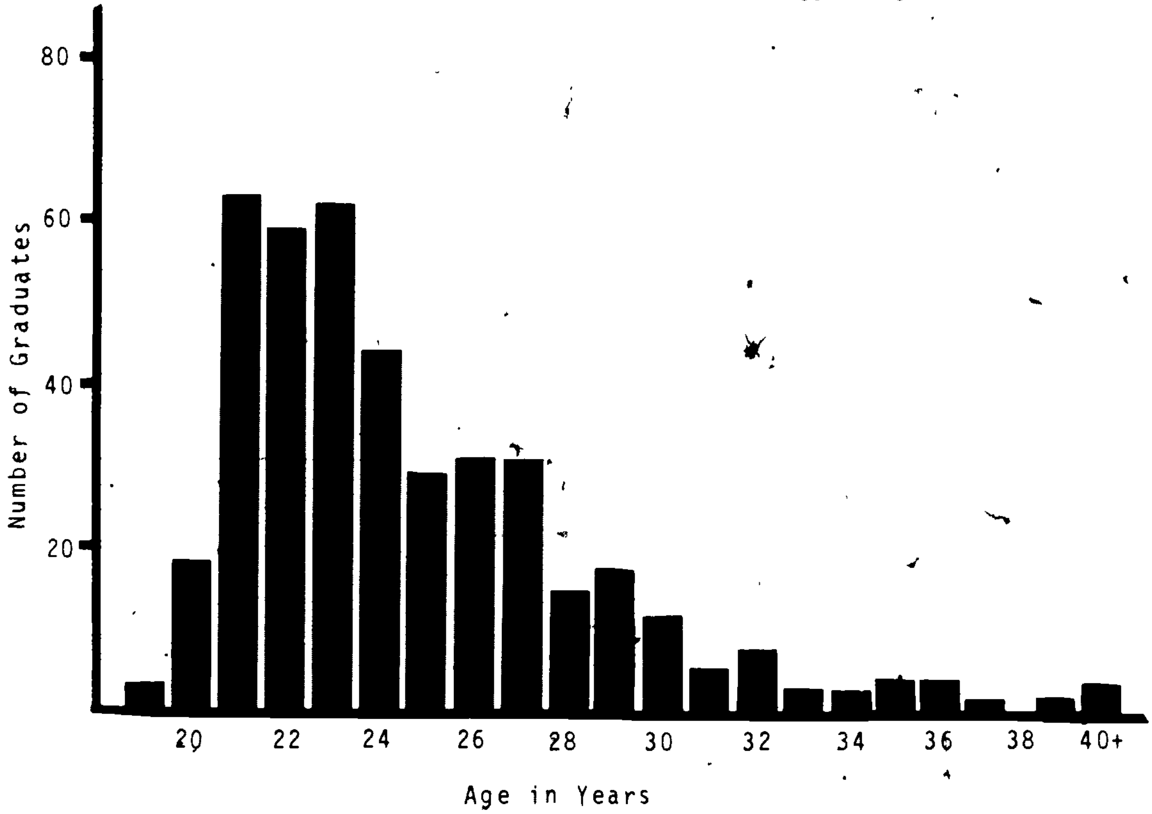
The mean monthly salary ($688) reported in 1970 by this sample of 409 graduates is equivalent to about $8260 per year. This figure may be compared to data obtained by the Engineering Manpower Commission slightly earlier in 1969.[1] EMC reported, for 1143 technicians who had been on the job two years, a mean annual salary of $7650 and an upper quartile salary of $8250. That the mean salary reported here ($8260) is 8 percent higher than the mean reported by EMC ($7650) may be related to several factors: (1) a bias of this sample created in the selection of participating institutions; (2) a bias created by the respondents (those with higher salaries tend to respond in a greater proportion to questions about salary); (3) general increases in salary levels between 1969 and 1970; and (4) sampling error. That these sets of results are in reasonable agreement lends support to the assumption of sample validity.

Age

Graduates' reported their age (Questionnaire Item 8). The distribution of ages as reported is shown in Figure 14, for the 412 graduates in the sample. The mean age is estimated to be slightly less than 25 years, the median, 24 years. In previous research (see the results reported in Chapter 7), the most frequently reported age of students in associate degree engineering technology programs was found to be 19-20 years. Assuming two years as the duration of an associate degree program, students can be predicted to graduate at 20-22 years of age, and to be initially employed (i.e., first job or

[1]Engineering Manpower Commission of the Engineers Joint Council, *Salaries of Engineering Technicians, 1969,* The Council, March, 1970. See salary data, p.19, for "Graduate Technicians, Associate Degree, Entire U.S."

FIGURE 14.--Distribution of Ages Reported by a Sample of 412 Graduates of Associate Degree Engineering Technology Programs.



first 18 months after graduation) at 20-24 years of age, with 23 years being the predictable mean. That the results here show a mean age slightly higher than the predictable mean may imply one or more of the following: (a) there was a different pattern of attendance by age groups two years ago than that which prevails currently; (b) the mean age of graduates is higher than the predictable mean age because of interim military service; (c) the presence in this sample of a few men 35-50 years old has biased the results; or (d) an appreciable number of students who attended part-time, and hence required more than the predictable two years to graduate, have affected the results.

The distribution of graduates' ages by region and by technical specialty is shown in Table 58, where cells with statistically significant differences are marked with an asterisk. The table reveals that technicians in Region 1 (the Northeast) are younger than their counterparts elsewhere in the country.

TABLE 58.--Distribution by Region and by Technical Specialty of the Ages (Means) of 412 Graduates of Associate Degree Engineering Technology Programs.

Technical Specialty	Region					
	1	2	3	4	5	US
Civil	22*	24	-	25	25	24
Electrical	23*	27	25	27	27	26
Mechanical	22*	24	24	25	25	24
Other	22*	27	24	23	23	24
TOTAL	22*	25	24	26	24	25

<u>Educational Experiences Since Graduation</u>

Graduates reported on the educational or training experiences they had completed since graduation or in which they were engaged at the time of response (Questionnaire Items 9 and 10). Summary results are given in Table 59. Many respondents listed more than one kind of further education experience, so that total frequency in Table 59 is greater than the size of the sample.

It can be noted that in-service or on-the-job training was given by the employers of approximately two-thirds of these graduates,

TABLE 59.--Educational and Training Experiences Since Graduation Reported by a Sample of 412 Graduates of Associate Degree Engineering Technology Programs.

Kind of Experience	Frequency of Response	
	Number	Percentage
In-service or on-the-job training provided by the employer	268	65
Courses in public or private schools arranged for and paid for by the employer	57	14
Courses in public or private schools selected by employee but paid for--wholly or in part--by the employer	82	20
Courses in public or private schools at the employee's choice and expense	91	22

and about 1 out of 7 graduates attended courses which were arranged for and paid for by their employers. No pattern of differences by region or discipline were apparent when the raw data were analyzed in detail.

Approximately 20 percent of these graduates attended courses paid for, at least in part, by their employers; detailed analysis indicated that this fringe benefit was somewhat less available to civil technology graduates and to graduates from institutions in the West.

Slightly more than 1 in 5 of the graduates reported attending school at their own expense; no differences by region or specialty were apparent.

It is interesting to examine the total frequency of the two middle items in Table 59; this combination represents the frequency with which employers of technicians had made some contribution to the further education of their employees. Approximately 34 percent of the technicians in this sample reported such to be the case, although it was noticeably less so for Civil technicians when data for these graduates were examined separately.

The graduates were also asked to state the purpose of any further educational or training experiences they had undergone since graduation. A summary of the responses is given in Table 60. Many graduates, of course, made multiple responses.

Approximately one-third of the graduates in the sample received orientation and instruction in company policy; slightly more than

TABLE 60.--Purposes of Further Education Reported by 412 Graduates of Associate Degree Engineering Technology Programs.

Purpose of Education or Training	Frequency of Response Number	Percentage
Orientation and instruction in company policy	143	35
Acquiring knowledge directly needed on job	222	54
Acquiring skills directly needed on job	145	35
Preparation for advancement to a higher position	122	30
Expectation of seeking another position and employer	33	8
Self-improvement only	64	16

one-half required further knowledge directly needed on the job; and about one-third needed additional skills for their jobs. The Civil technology graduates in the sample reported the purpose of acquiring skill less frequently than others; apparently the skills they need for the first job (surveying, drafting, etc.) are well covered in their associate degree programs. Graduates in the North Central region tended to report the purpose of skill acquisition more frequently than other graduates; one can conjecture that the nature of the school environment and the work environment may match less well in this region than in others.

About 30 percent of the graduates reported they had pursued further educational experiences in order to prepare for a higher position; 8 percent reported the expectation of changing both their employer and their job. These results imply the existence of both a potential for fairly rapid promotion to positions beyond those available for entry and a remarkably stable technical work force for the first 18 months of employment.

One graduate in six reported further education for personal improvement purposes only. This statistic raises several questions: Does such continued study represent a desire on the part of associate degree graduates to seek the higher status that an added degree might bring? Does it perhaps merely reflect an enthusiasm for learning acquired during the process of acquiring the associate degree? How well is this statistic (16 percent of associate degree graduates) a measure of the national "continuing education" market? Or is this response a convenient one to disguise other motivations? No answers are available, and further research is indicated.

Career Decisions

Graduates were asked to respond to a question related to the time of their career decisions (Questionnaire Item 11). Tables 61 and 62 display summaries of the responses, with distributions by technical specialty and by region. Entries in the tables are the percentages of graduates of each category which gave the indicated response; entries do not add to 100 percent because some graduates did not respond. The entries in the table suggest (1) that civil technology graduates perhaps were more likely to have made career decisions in high school, whereas graduates from most curricula delayed that decision until they were in college, and (2) that students in the northeast region were more likely to have made -

TABLE 61.--Time of Career Decision Reported by 412 Graduates of Associate Degree Engineering Technology Programs, Showing Percentage Distribution by Technical Specialty.

Technical Specialty	Time of Career Decision			
	Before High School	During High School	While in College	While Employed
Civil	3	44	30	20
Electrical	8	24	40	21
Mechanical	4	21	54	11
Other	5	36	43	12
TOTAL	6	30	42	16

TABLE 62.--Time of Career Decision Reported by 412 Graduates of Associate Degree Engineering Technology Programs, Showing Percentages Distribution by Geographic Region of United States.

Geographic Region	Time of Career Decision			
	Before High School	During High School	While in College	While Employed
Northeast	4	47	31	11
Southeast	3	37	42	14
North Central	9	16	59	16
South Central	7	23	35	25
West	8	16	47	22
TOTAL U.S.	6	30	42	16

early career decisions. It is interesting that few graduates, only 6 percent of the sample, reported having made career decisions before their high school years.

Factors of Influence

Graduates were asked what factors they perceived as having influenced their career decisions (Questionnaire Item 12). A Summary of responses is shown in Table 63. Some graduates listed several factors, so the sum of percentages in the table exceeds

TABLE 63.--Factors Cited as Having Influenced the Career Decisions of 412 Graduates of Associate Degree Engineering Technology Programs.

Factor	Percentage of Graduates Citing Factor[a]
Influenced by father or other members of family in similar occupations	20
Influenced by someone, other than a relative, in the occupation	32
Influenced by a high school teacher or counselor	15
Developed an interest while in another job	24
Developed an interest from articles and advertisements in newspapers, other media	11
Other (military service, etc.)	17

[a]Total exceeds 100 percent because of multiple responses by some graduates.

100 percent. It may be important that approximately one-half of these graduates listed the influence of some person (relative or non-relative) in the same or a similar occupation as having affected their career decision; the influence of high school teachers or counselors was cited appreciably less often.

These graduates were also asked what factors had influenced them in their choice of institution (Questionnaire Item 13). Table 64 shows a summary of the responses. As shown in the table, factors of "location" and "cost" were mentioned much more often than any others; it is interesting that "information from friends" was cited more frequently than "advice from parents" or "advice from high school counselor." The responses from this sample of graduates were somewhat similar to the responses from a sample of students studied previously. Table 65 shows the relationships between the two sets of data. A possible inference to be drawn from Table 65 is that students currently enrolled in associate degree engineering technology curricula were, in selecting a college, even less influenced by other persons than were their immediate predecessors. The implication for guidance is that information on schools should reach directly the students to be recruited. An alternative inference is that location

TABLE 64.--Factors Cited as Having Influenced the College Choices of 412 Graduates of Associate Degree Engineering Technology Programs.

Factor	Percentage of Graduates Citing Factor[a]
Location	63
Costs	42
Advice from Parents	10
Advice from high school counselor	21
Information from friends	32
Publications of Institution	32
Other	11

[a]Total exceeds 100 percent because of multiple responses.

TABLE 65.--Comparison of College-Choice Influences, Recent Graduates and Current Students, Associate Degree Engineering Technology Programs.

Factor Influencing College Choice	Percentage Citing Factor[a]	
	Graduates	Students[b]
Location	63	63
Costs	42	43
Influence of parents, Teachers, etc.	31	2
Influence of friends	32	19
Other	43	45

[a]Totals exceed 100 percent because of multiple responses.

[b]Adapted from Table 47, chapter 7, herein.

and costs have become such major considerations in choice of a college that other factors have assumed relatively unimportant roles.

Satisfaction with Education

The graduates in this sample were asked their opinions about how well their educational experience had prepared them for their first employment (Questionnaire Item 14). The responses, by technical specialty of the graduates are summarized in Table 66, where entries are the percentages of graduates of each category giving the indicated responses. As can be noted in the table, few (only 5 percent of the sample) perceived themselves as "inadequately" prepared for their first employment. About 42 percent of the sample stated they were "excellently" prepared for their first job, the remainder (slightly more than half) rating their preparation as adequate. Civil technicians, as a group, were the most enthusiastic, nearly two-thirds rating their programs as excellent; mechanical technicians gave slightly less positive ratings than the other groups. If the percentages for "excellent" and "adequate" are combined, then about 94 percent of all graduates had judged their educational experiences to be adequate or better for their first job.

An analysis of these responses by geographic region was also made, but no significant differences in response pattern were detected.

TABLE 66.--Perceptions of 412 Graduates of Associate Degree Engineering Technology Programs on the Adequacy of their Education

Technical Specialty	Percentage of Graduates Giving Rating			
	Excellent	Adequate	Inadequate	No Response
Civil	64%	33%	0%	3%
Electrical	39	58	3	0
Mechanical	41	49	8	1
Other	33	58	8	1
TOTAL	42%	52%	5%	1%

Job Activities of Graduates

Item 15 of the Questionnaire sought to elicit data from which an analysis of technician's job activities might be made in terms of the frequency of performance of certain tasks. The tasks considered were defined on the questionnaire instrument itself (see Appendix F). Respondents marked the frequency with which they performed each task as "About once per month," "About once per week," or "Daily or nearly so."[1] Only 299 of the 412 graduates in the original sample completed this item satisfactorily; thus, a sub-sample of 299 graduates, distributed by technical specialty and by region as indicated in the N-matrix of Figure 15, formed the data base for the analyses which appear in this section.

FIGURE 15.--Distribution by Region and by Technical Specialty of a Sub-Sample of 299 Graduates of Associate Degree Engineering Technology Programs.

Technical Specialty	Region					
	1	2	3	4	5	U.S.
Civil	-	20	-	3	10	33
Electrical	23	14	12	40	22	111
Mechanical	12	18	7	12	12	61
Other	30	14	23	12	15	94
TOTAL	65	66	42	67	59	299

Reduction of data for this item involved the following steps:

(1) assigning raw data to the appropriate cells as implied by the N-Matrix of Figure 15,

(2) tallying by cell the "monthly," "weekly" and "daily" performance rate frequencies which were reported,

(3) computing "weighted task scores" for each cell by evaluating the monthly, weekly and daily performances respectively at one, three and five times their frequences and then summing these results,

(4) dividing the weighted task scores from step (3) by the corresponding cell sizes to obtain a "task performance index";

(5) assigning each task and its value of task performance index to a "task Cluster" (see Table 67 for a listing of tasks by cluster);

[1]Performance frequency categories of "Never" and "Less than once per month" also appeared; the responses in these categories, however, proved not to contribute to the results and hence were not used in the analysis. In addition, estimates of time spent per week on each task were requested; these responses were also rejected from the analysis because of internal inconsistencies in most of the questionnaires returned.

TABLE 67.--Tasks and Task Clusters Associated with the Jobs Held by Engineering Technicians, as Adopted for a Job Activity Profile Analysis

Task Cluster	Task[a]
1. Design Related Tasks	1. Analysis 2. Derivation 3. Design 4. Design Assistance
2. Development Related Tasks	1. Building Things 2. Data Recording 3. Instrumentation 4. Experimentation 5. Evaluation 6. Recommending Modifications 7. Performance Testing 8. Materials Testing 9. Reliability
3. Drafting Related Tasks	1. Check Drawings 2. Drafting, design 3. Drafting, detail 4. Drafting, layout
4. Geodosy Related Tasks	1. Mapping 2. Surveying, Instrument Man 3. Surveying, Rod Man
5. Supervision Related Tasks	1. Communications 2. Coordination 3. Expediting 4. Planning and Scheduling 5. Supervision 6. Training 7. Writing Change Notices 8. Writing Standard Practices
6. Process Related Tasks	1. Manufacturing 2. Process Control 3. Inspection, Quality Control 4. Methods, Quality Control 5. Methods, Production 6. Plant Layout
7. Equipment Related Tasks	1. Operating 2. Installation 3. Calibration and Adjustment 4. Inspection, Maintenance 5. Troubleshooting 6. Repair 7. Modification
8. Cost-Sales Related Tasks	1. Cost Estimating 2. Quantity Estimating 3. Writing Specifications 4. Purchasing 5. Writing Proposals 6. Marketing and Sales 7 Customer Service
9. Reporting Tasks	1. Verbal Reports 2. Writing Reports
10. Other	1. Company Training 2. Programming 3. Technical Publications

[a]For definitions of tasks, see Appendix F

(6) computing the mean of the values of the task performance indices for the tasks within each task cluster;

(7) plotting all the values of task performance index from step (5) and task cluster mean from step (6) to obtain a "job activity profile"; and

(8) comparing the resulting diagrams for each cell in an effort to detect any differences in job activity profiles which could be related to the technical specialty or the geographic region of the graduates.

The data are presented in Table 68; a discussion of some of the results follows:

Job Activity Profiles.--Figures 16, 17, and 18 show job activity profiles by technical specialty for graduates of associate degree curricula in civil, electrical/electronics, and mechanical engineering technology, respectively; Figure 19 is a profile for graduates from all other curricula and Figure 20 is a composite job activity profile for all graduates in this sub-sample of 299 men. On each figure, values of a "task performance index" (definition *supra*) are displayed as

FIGURE 16.-- Job Activity Profile for Civil Engineering Technicians in Entry Level Jobs

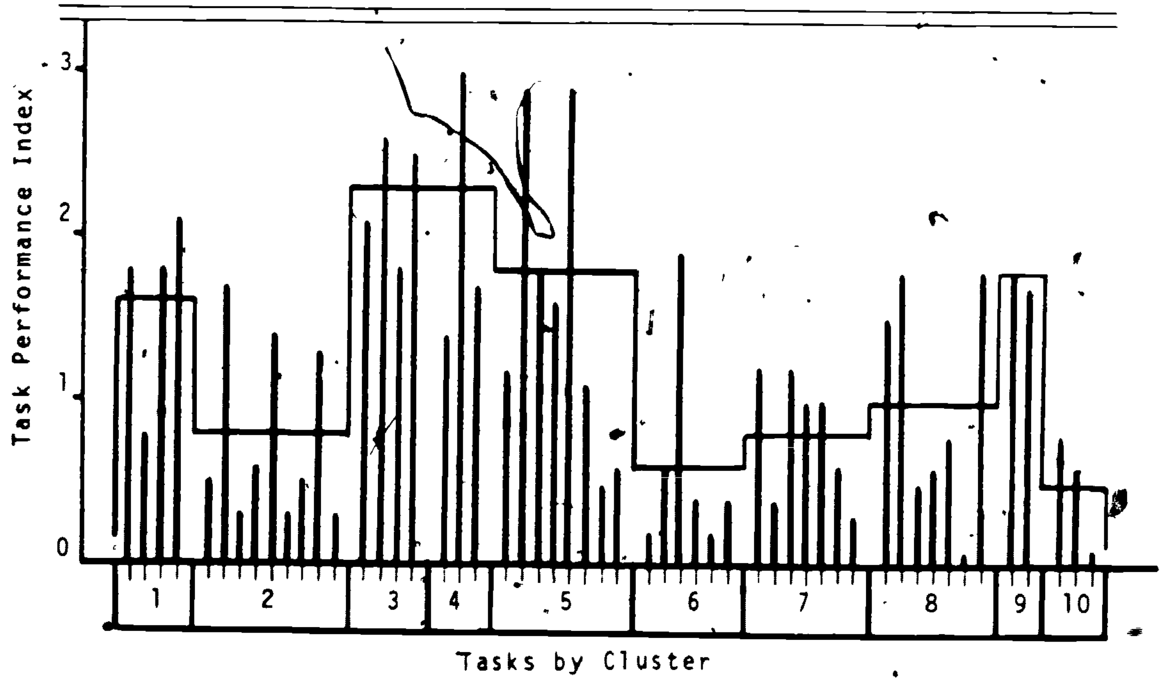


TABLE 68.--Task Performance Index Values by Specialty and By Region For Associate Degree Technicians in Entry Level Jobs[a]

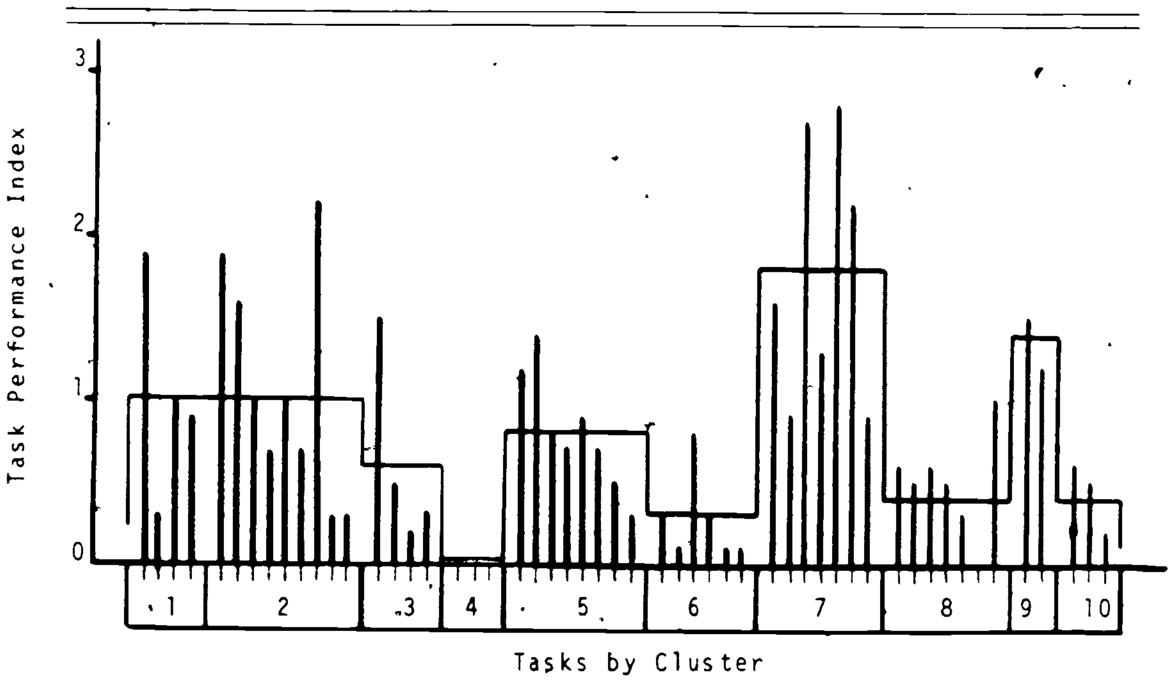
Task Cluster	Task	Civil				Electrical						Mechanical						Other						All Technicians
		2	4	5	US	1	2	3	4	5	US	1	2	3	4	5	US	1	2	3	4	5	US	
1	1	2.4	1.7	.8	1.8	2 4	1 3	2.5	1.9	1 2	1 9	1 6	2 2	2.9	2 6	2.8	2 4	2 6	3.5	1 6	3 3	2 3	2 5	2 2
	2	.6	2 7	8	8	.6	4	2	.1	3	3	-	9	1 1	5	.5	6	3	6	2	6	-	3	4
	3	2.0	1.0	1 4	1 8	1 4	1 9	7	.8	8	1 0	1 9	3.7	1 6	2.7	1 4	2 5	1 4	1 4	1 9	1.2	2 1	1.6	1 6
	4	2 2	1 3	2 1	2 1	1 2	1 1	.8	.7	1 0	9	1.1	2.4	.1	1.6	1.1	1.6	1 3	.9	1 5	1 6	2 6	1 5	1.4
2	1	4	1 0	6	5	2 2	2 2	1 8	1 6	1.7	1 9	1.4	.8	2 0	2 4	2 5	1.7	.9	2	9	4	3	5	1 3
	2	1.8	1 7	1 4	1 7	2 0	1 1	1.8	1 5	1.7	1 6	2.2	.7	2.9	2 5	1 9	1 9	.8	1 8	1.3	1 8	4	1 1	1 5
	3	1	1 0	5	3	6	1 5	8	1 3	.8	1 0	6	3	1 9	.8	9	8	.8	.6	1 0	1 0	-	7	8
	4	8	1 7	-	6	1.0	1 1	-	.4	1 0	7	6	.8	1.4	1 3	1 2	1 0	6	3 6	7	8		5	7
	5	1 8	3	9	1.4	9	6	1 0	1 1	1 3	1 0	1 8	3	2 3	1 4	1 1	1 2	1 2	2 1	1 1	7	3	1 1	1 1
	6	.5	3	-	.3	1 3	1 1	4	6	4	7	7	1 8	1 6	1 7	1 3	1 4	7	1 1	9	1 3	-	8	8
	7	8	1.0	1	5	1 0	1 6	2 2	2 6	3 1	2 2	8	4	1 4	2 2	6	1 0	1 2	2	1	1 2	1	9	1 4
	8	1 6	1 7	5	1 3	2	4	4	2	.5	3	7	3	1 9	1 7	5	9	5	2	6	7	2	4	6
	9	3	-	3	3	.3	.6	-	3	.4	3	.2	1.1	-	1.2	.2	.6	5	7	8	-	3	5	.4
3	1	2 9	-	1 1	2 1	1 8	2 4	1 8	1 2	9	1 5	2 0	3 0	7	2 5	1 2	2 1	1 4	1 9	1 3	8	2 7	1 6	1 7
	2	2 8	-	3 1	2 6	5	9	2	6	4	5	1 4	2 8	1 1	2 4	1 1	1 9	9	8	2 1	2 8	2 6	1 7	1 4
	3	1 8	7	2 0	1 8	2	1	2	2	2	2	1 6	2 9	9	2 3	1 4	2 0	1 0	7	1 6	2 8	3 6	1 7	1 2
	4	2 0	2 7	2 8	2 5	.4	8	-	2	.3	3	.8	2.3	.9	2.2	1.0	1.5	1 0	1 1	1 8	2 0	3 4	1 7	1.2
4	1	1 5	-	1 8	1 4	-	2	-	-	-	-	-	-	7	-	-	.1	2	3	3	-	.1	2	2
	2	3 3	-	3 3	3 0	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4	1	3	3	3
	3	1 1	-	3 4	1 7	-	.2	-	-	-	-	-	-	-	-	-	-	2	1	3	-	3	2	.3
5	1	1 2	1 0	1 3	1 2	1 4	1 7	1 4	1 1	9	1 2	8	2 2	2 1	1 1	2 3	1 7	1 7	3 6	1 1	2 6	5	1 7	1 5
	2	3 6	2 0	1 5	2 9	1 3	2 1	1 2	1 4	9	1.4	1 2	3 5	7	1.9	2 3	2 2	1 5	3 9	1 0	2 7	1 7	1 9	1 9
	3	2 3	2 7	5	1 8	1 0	1 5	2	5	1 0	8	1 5	2 0	-	1 8	1 2	1 3	1 3	1 9	6	1 0	3	1 0	1 1
	4	1 9	2 0	8	1 6	1 1	1 1	5	5	3	7	9	1 6	-	8	8	1 0	1 2	2 1	8	9	6	1 1	1 0
	5	3 6	1 7	2 1	2 9	7	1 8	1 4	9	5	.9	8	2 1	2 6	1 3	6	1 4	1 3	2 7	1 2	8	5	1 3	1 4
	6	1 2	1 7	8	1 1	7	1 2	.8	5	7	7	2	4	9	.2	1 0	5	4	1 1	3	8	4	5	7
	7	5	7	.5	5	4	4	6	9	-	5	4	1 1	4	1 2	8	8	5	1 9	6	2.0	7	1 0	7
	8	4	1.0	.5	6	.6	.6	.2	.3	-	.3	.1	.9	-	4	-	4	.2	9	5	3	3	4	.4
6	1	-	1.7	-	2	-	-	-	5	7	.3	-	.6	.1	1 2	8	8	-	.1	3	-	-	1	.3
	2	.9	1 0	-	6	-	.6	1	1	-	.1	5	.2	7	.2	5	.4	3	.4	7	-	-	3	.3
	3	2 2	2 0	1.1	1 8	4	1 1	7	1 2	.5	8	1.5	1 3	1.9	1.5	1 4	1 5	1.2	1 7	7	-	4	7	1 0
	4	6	3	-	4	.4	-	-	.4	.1	.3	2	.3	1.3	6	2	5	.2	7	1	3	-	2	3
	5	2	3	-	2	2	-	-	-	.2	.1	.3	7	1 3	.9	.7	7	.3	8	2	3	5	4	3
	6	6	.3	.3	4	.6	1	-	-	-	.1	.8	.5	-	-	.1	3	-	.4	.4	1	1	2	.2
7	1	1 2	1 7	1 1	1 2	4	2 2	1 4	1 9	1 8	1 6	6	1	1 4	1 9	2 3	1 1	1 0	2	3	-	-	7	1 2
	2	3	1 7	-	4	3	1 1	1 4	9	1 0	9	1 8	5	9	5	2 1	1 1	1 1	8	5	-	-	6	.8
	3	1 2	1 7	1 0	1 2	1 6	2 6	2 7	3 0	3 6	2 7	1 4	8	1 6	1 4	2 0	1 4	.6	1 3	1 3	9	-	1 1	1 8
	4	1 2	2 0	4	1 0	2	2 6	2 2	1 4	1 1	1 3	1 2	8	2 3	1 1	2 5	1 5	1 3	1 4	6	7	1	9	1 2
	5	1 4	1 7	.2	1 0	2 5	3 4	2 8	4 1	4 0	2 8	1 2	1 4	2 7	2 0	1 8	1 7	1 9	1 9	1 3	1 1	4	1 5	2 0
	6	7	1 7	1	6	4	3 6	2 2	2 0	3 4	2 2	1 6	-	2 0	9	2 2	1 1	1 4	5	4	-	-	6	1 3
	7	.5	.3	-	.3	1.0	1.1	.7	.8	1.1	9	9	7	1 3	1 8	2 4	1 4	4	1	7	1	7	4	8
8	1	2 0	2 0	3	1 5	5	9	1 0	6	3	6	8	2 4	1 6	5	9	1 3	1 1	1.8	9	9	8	1 1	1 0
	2	3 4	1 3	6	1 8	7	.9	6	2	4	5	6	1 9	-	4	1 6	1 1	9	1 7	5	2	3	7	8
	3	4	7	4	5	7	1 6	-	5	-	6	1	1 5	7	8	4	8	-	1 9	7	2	5	6	4
	4	8	1 7	.	6	9	1 5	2	3	-	5	8	1 3	7	4	1 7	1 0	7	6	6	2	-	5	6
	5	7	2 3	5	8	1	1 1	2	3	2	3	3	9	-	-	3	4	4	1 1	1 1	9	1 3	9	6
	6	-	1 0	-		-	-	-		2	-	1	9	-	-	1	3	4	1 1	4	-	3	4	2
	7	2.4	1.7	.8	1.8	1.1	1.1	2.2	.6	1.0	1.0	5	1 3	3	5	1 1	8	1 1	1 0	7	8	4	8	1 0
9	1	2 0	2 3	1 4	1 8	.4	2 5	1 0	1 9	1 7	1 5	1 9	1 7	3 6	1 6	1 9	2 0	1 2	2 5	2 3	2 4	-	1 7	1 7
	2	1 8	3 0	1 1	1 7	1.4	1 6	1 3	1 4	4	1 2	7	9	2 6	6	1 2	1 1	1 2	2 1	1 9	1 4	3	1 4	1 3
10	1	6	1 7	9	8	6	1 1	6	2	1 0	6	3	3	9	6	1 1	6	3	7	1	3	3	3	5
	2	5	-	1	6	6	2	1 2	2	8	5	4	1	-	1	-	3	7	-	3	5	1	4	4
	3	2	-	-	1	3	7	1	2	-	2	4	4	-	7	2	3	1	6	-	9	1 0	4	3

[a]For definitions of Tasks and Task Clusters, see Table 67, for definition of Task Performance Index, see text, *supra*.

vertical lines for each of 53 "tasks" (definitions in Appendix F) in 10 different "task clusters" (definition *supra*, Table 67); in addition, task cluster means are shown on each figure. The resulting profiles indicate the relative frequency of performance of certain tasks by engineering technicians of various kinds in entry level jobs. These profiles give some insights into the manpower utilization practices of employers, predict the job activities which newly graduated technicians may expect, and have some implications for educators. Some caution in interpretation is urged: the task performance index is only a quantitative measure, not a qualitative one; it may well be true that certain tasks performed very infrequently are the most important ones in a technician's job description and the *sine qua non* of his employment. These profiles, however, have important and useful descriptive value within the limits noted.

Observations on Profiles.--Examination of Figures 16 through 20 yeild certain observations about the characteristics of the entry level jobs which various kinds of technicians have. Civil technicians,

FIGURE 17.--Job Activity Profile for Electrical/Electronics Engineering Technicians in Entry Level Jobs



for example, show a high profile in drafting-related, geodosy-related and reporting tasks with limited activity directed toward tasks in the process-related cluster. Electrical/electronics technicians, on the other hand have a high profile in equipment-related tasks, a moderately low profile in most areas, and--predictably--a zero profile in geodosy-related tasks. Mechanical technicians have a high profile in drafting-related and design related task clusters, moderately high profiles in supervision-related and equipment-related tasks, and a zero profile in geodosy-related tasks. The "other" group, Figure 19, consists of a variety of technicians--aeronautical, air conditioning, building construction, chemical, drafting, environmental, etc.--with a diversified employment; hence, it is to be expected that the identifying characteristics of employment of such a group would become blurred unless such characteristics were common to the employment of most members of the group. Indeed, only the drafting-related tasks appear with a high profile.

Figure 20, which is the composite profile for the entire sample, serves to indicate the relative frequencies with which a variety of

FIGURE 18.--Job Activity Profile for Mechanical Engineering Technicians in Entry Level Jobs.

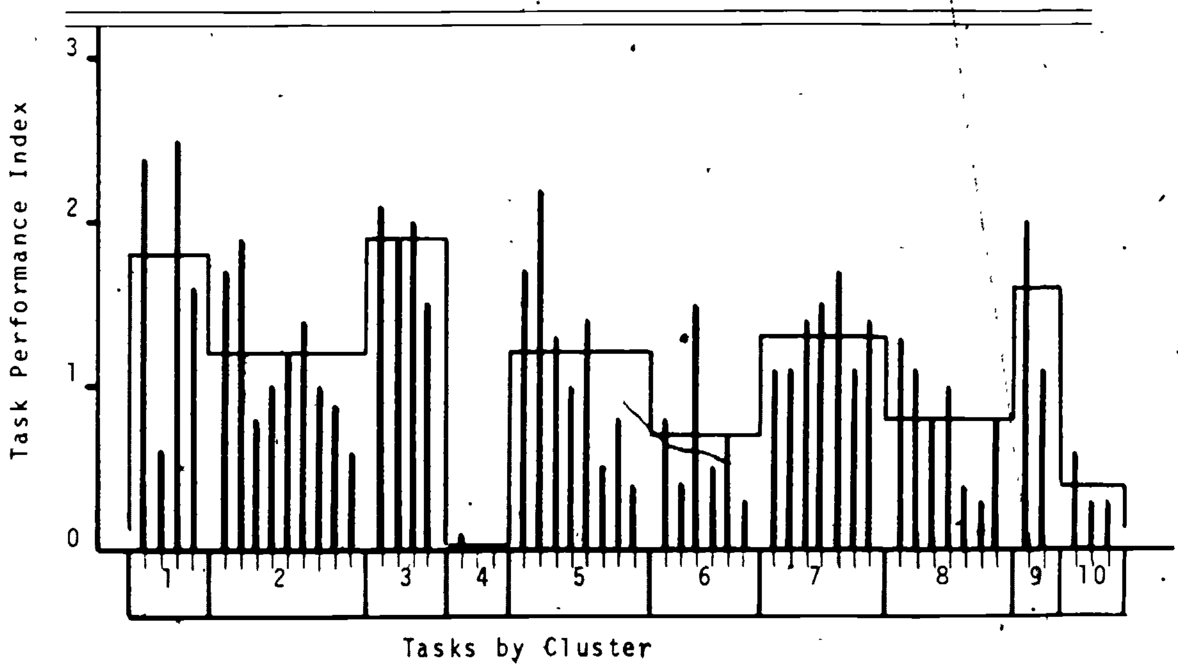


FIGURE 19.--Job Activity Profile for Engineering Technicians Other Than Civil, Electrical/Electronics, or Mechanical in Entry Level Jobs

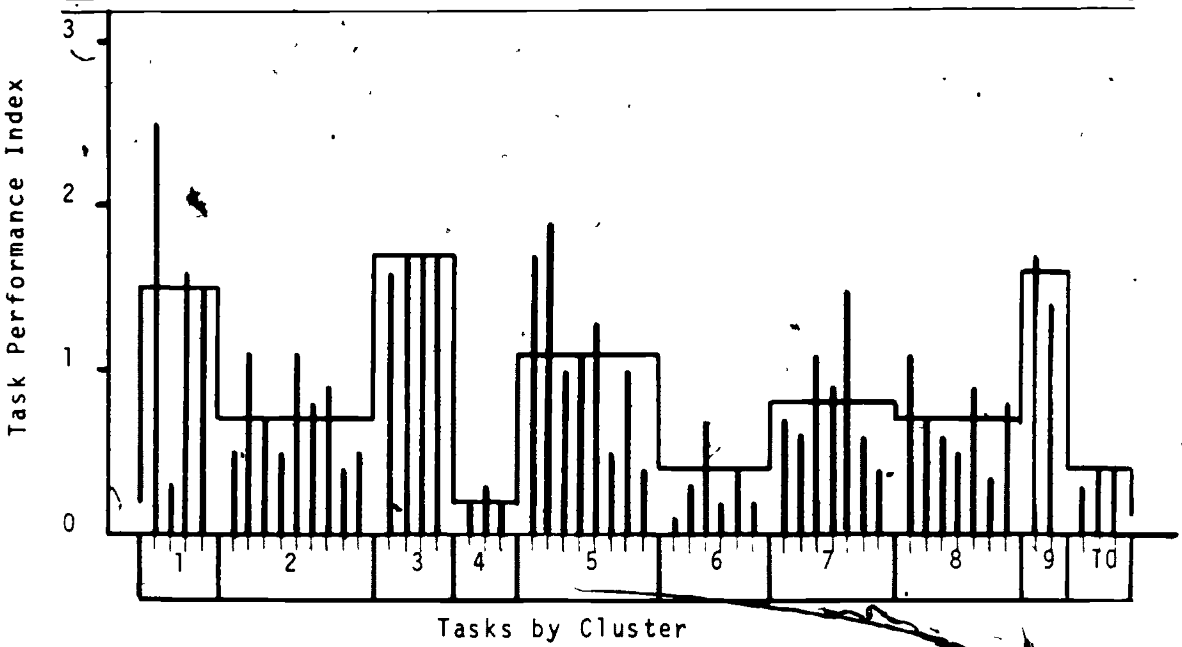
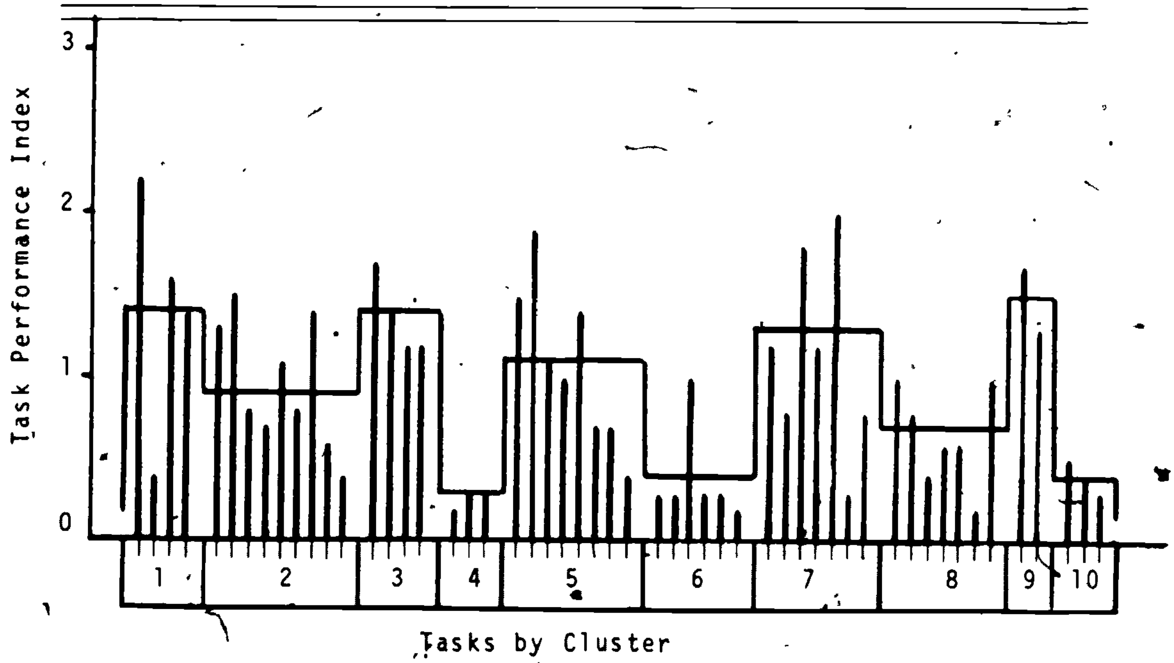


FIGURE 20.--Composite Job Activity Profile for a Mixed Sample of 299 Engineering Technicians in Entry Level Jobs.



tasks are performed by technicians of all types. For example, the low task performance index for the geodosy-related cluster implies that there is only a small proportion of the total population of associate degree technicians engaged frequently in mapping or surveying operations. It is interesting to note that the "reporting" cluster (i.e., verbal reports, writing reports) has the highest value of task performance index on this diagram; evidently, responsibilities for reporting are common to most technician jobs.

Emphasis on Specific Tasks.--The entry level jobs of technicians of various types seem to be characterized by frequent performance of certain specific tasks. The most frequently performed tasks are usually, though not always, associated with task clusters having high cluster means. Table 69 lists relevant data for civil, electrical/ electronics, and mechanical technicians. In the table, the ten tasks of highest task performance index are listed in rank order; where the task has a high index it is marked with a double asterisk, and a single asterisk is used where the index is moderately high.[1] These lists of frequently performed tasks indicate in a general way the major focus of the job activities of the three kinds of technicians considered. The civil technician, for example, is often on a surveying team, and has considerable responsibility for supervising the work of others; he also is often found working at the drawing board, designing, assisting to design, or doing layout work. The electrical/ electronics technician is principally a troubleshooter; he identifies problems with equipment, calibrates and adjusts, repairs, tests and does analysis. The mechanical technician is seemingly used broadly, in design, analysis, coordination, drafting, reporting, data recording, and building models or prototypes.

Regional Differences.--The job activities of technicians show some intra-specialty differences by geographic region. Table 70 indicates in broad fashion some of the major differences, in terms of the relative frequency of performance of certain task clusters; this table has been constructed from the detailed data of Table 67. From Table 70 the following interpretations can be made.

> Civil Technicians: The job activities of civil technicians employed in the Southeast region of the United States apparently are more characterized by supervisory responsibilities (communications, coordination, planning and scheduling, supervising,

---

[1]For the analysis here, task performance indices were rated as follows: under 0.6, "low;" 0.7-1.6, "moderately low;" 1.7-2.6, "moderately high;" 2.7 and above, "high".

TABLE 69.--Ten Most Frequently Performed Tasks: Civil, Electrical/Electronics, and Mechanical Technicians[a]

Rank Order of Frequency	Tasks, by Technical Specialty of Technician		
	Civil	Electrical/Electronics	Mechanical
1	**Surveying, Inst. Man	**Troubleshooting	*Design
2	**Coordination	*Calibration and Adjustment	*Analysis
3	**Supervising	*Repair	*Coordination
4	*Design Drafting	*Performance Testing	*Check Drawings
5	*Layout Drafting	*Analysis	*Detail Drafting
6	*Design Assistance	*Building Things	*Verbal Reports
7	*Check Drawings	Data Recording	*Data Recording
8	*Inspection, Qual. Control	Operating	*Design Drafting
9	*Quantity Estimating	Check Drawing	**Building Things
10	*Detail Drafting	Verbal Reports	*Troubleshooting

[a]Entries marked with a double asterisk (**) are tasks with a "high" task performance index; entries marked with a single asterisk (*) have a "moderately high" index.

TABLE 70.--Task Cluster Means, Job Activities, for Associate Degree Technicians in Entry Level Jobs, by Region and by Specialty.

Technical Specialty	Task Cluster[a]	Region 1	2	3	4	5	U.S.
Civil[b]	1		1.8			1.3	1.6
	2		.9			.5	.8
	3		2.4			2.3	2.3
	4		2.0			2.8	2.3
	5		2.1			1.0	1.8
	6		.7			.2	.6
	7		.9			.4	.8
	8		1.2			.4	1.0
	9		1.9			1.3	1.8
	10		.4			.3	.5
Electrical/ Electronics	1	1.4	1.2	1.1	.9	.8	1.0
	2	1.1	1.1	.9	1.1	1.2	1.0
	3	.7	1.1	.5	.6	.6	.6
	4	-	.1	-	-	-	-
	5	.9	1.3	.9	.8	.5	.8
	6	.3	.3	.1	.4	.2	.3
	7	.9	2.4	1.9	2.0	2.3	1.8
	8	.6	1.0	.3	.4	.3	.4
	9	.9	2.1	1.2	1.2	1.1	1.4
	10	.5	.7	.6	.2	.6	.4
Mechanical	1	1.2	2.3	1.4	1.9	1.5	1.8
	2	.9	.7	1.7	1.7	1.1	1.2
	3	1.5	2.8	.9	2.4	1.2	1.9
	4	-	-	.2	-	-	-
	5	.7	1.7	.8	1.1	1.1	1.2
	6	.6	.6	1.2	.7	.6	.7
	7	1.3	.6	1.7	1.4	2.2	1.3
	8	.5	1.5	[illegible]	.4	.9	.8
	9	1.3	1.3	3.[illegible]	1.1	1.6	1.6
	10	.4	.2	[illegible]	.8	.5	.4
Other	1	1.4	1.6	1.3	1.7	1.7	1.5
	2	.8	1.2	.9	.9	.2	.7
	3	1.1	1.1	1.7	2.1	3.1	1.7
	4	.3	.2	.3	-	.2	.[illegible]
	5	1.0	2.3	.8	1.4	.6	1.1
	6	.3	.7	.4	.1	.2	.4
	7	1.2	.9	.9	.4	.2	.8
	8	.7	1.5	.7	.5	.5	.7
	9	1.2	2.3	2.1	1.9	.1	1.6
	10	.4	.4	.1	.6	.4	.4

[a]See Table 67 for definition.

[b]Groups too small for anlaysis in Regions 1,3 and 4.

etc.) than in the west.

Electrical/Electronics Technicians: The general characteristics of the job activities of electrical/electronics technicians are similar throughout the United States; in the northeast, however, such technicians perform equipment-related tasks appreciably less frequently and are slightly more associated with design-related tasks.

Mechanical Technicians: Job activities of mechanical technicians in the Southeast reflect a relationship with cost-sales activities which is not characteristic in other regions. Mechanical technicians in the North Central region are atypical of the group as a whole: their job activity profiles are higher in development-related and process-related tasks, and considerably lower in the drafting-related and equipment related clusters.

Other Technicians: For technicians other than those in civil, electrical/electronics or mechanical specialties, the regional differences are minor: in the southeast, these technicians are more associated with cost-sales activities; in the West, such technicians apparently have lesser association with reporting-related and with equipment-related activities.

Summary

Graduates of associate degree curricula in engineering technology responded to a questionnaire designed to elicit information related to job titles, salaries, continuing education, factors which had influenced college-choice, and job activities. More than 400 usable responses, representative of the graduates of 16 institutions in all parts of the country, were subjected to analysis. The graduates included were men in their first job (or first 18 months) since graduation.

Job titles most often included the word "technician," modified or unmodified; nearly 30 percent of the titles reported were of this sort. Job titles containing the nouns "aide," "assistant" or "associate" appeared with appreciable frequency, as did titles including the noun "engineer."

Salaries, as reported by the graduates, had a mean value of $688 per month. Civil engineering technicians appear to command slightly lower salaries than other kinds of technicians, and salaries of technicians in the western region of the country appear to lag salaries in other regions. Technicians in the North Central region reported slightly higher salaries than the national average. Comparisons of mean salaries by technical specialty and by region in no case, however, revealed a gross variation.

The technicians in this sample had a mean age of nearly 25 years, slightly more than the predictable mean; technicians in the northeast region appeared to be somewhat younger in the mean.

The pattern of responses suggests that participation in on-the-job and in-service training is a fairly common experience among newly-

hired technicians, for about two-thirds of the graduates in the sample reported such experiences. Moreover, 34 percent of the graduates reported attending school and having the costs of such education subsidized, wholly or in part, by their employers. The reasons most often cited for such schooling--other than those of orientation and instruction in company policy--were to gain knowledge or skills directly needed on the job (over 80% of the cases) or to prepare for advancement to a higher position (30% of the cases).

The graduates reported that their career decisions were made largely while they were in college (42 percent of the cases) or in high school (30 percent of the cases); the factor most often cited as having relationship to the occupational choice was the influence of an individual (relative or non-relative) in the same or a similar occupation. "Location" and "costs" were the factors most often cited as having affected the college-choice of these individuals.

Most technicians reported satisfaction with their collegiate studies; 52 percent rated their educational programs as "adequate" and 42 percent rated them "excellent." Civil technicians were especially enthusiastic.

A sub-sample of almost 300 technicians supplied detailed data from which a job activity analysis was made in terms of the frequency of performance of certain tasks. The job activity profiles which resulted suggested that tasks related to "reporting" were common to all technician jobs, that civil technicians were most frequently surveyors and supervisors, that electrical/electronics were principally "trouble-shooters" with responsibility for equipment, and that mechanical technicians are used most frequently in design-related tasks. Some minor regional differences in the utilization of technician manpower were apparent. A composite job activity profile for all technicians revealed that design-related, drafting-related, and reporting-related task clusters constitute the common elements of all technician jobs. The implications are clear for formal study of mathematics, graphics and communications in engineering technology education programs.

Careful study of the job activity profiles presented herein can be of benefit to employers, educators and technicians, for the profiles indicate what expectations a graduate of an engineering technology curriculum may have for his first job after graduation and give insights into the kinds of preparation which may prove especially relevant to such employment.

CHAPTER 9

CERTIFICATION OF ENGINEERING TECHNICIANS

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This paper describes briefly the progress in and prospects for the certification of engineering technicians. It contains a brief history of this certification program and gives summary statistics on the status of certification efforts.

The Certification Process

Certification is a formal method by which the individual engineering technician can achieve documentary recognition for his education, experience and competencies. In many cases, such certification may enhance the technician's opportunities for career advancement. This certification is a voluntary process, carried out under the auspices of a non-profit body, the Institute for the Certification of Engineering Technicians, 2029 K Street, N.W., Washington, D.C. 20006.

The Establishment of ICET

The Institute for the Certification of Engineering Technicians (ICET) is a part of the National Society of Professional Engineers, having been established by NSPE action on February 10, 1961. As early as 1958, NSPE had established a study committee to consider the emerging problem of providing a suitable means of recognizing engineering technicians and simultaneously differentiating their functions from those of professional engineers. The study committee deliberated for several years and submitted its report in June 1960, recommending the formation of a body which would (1) help to elevate performance standards of engineering technicians; (2) determine the competence of engineering technicians by means of investigations and examinations to test the qualifications of those who might apply; (3) grant and issue certificates to those engineering technicians who apply and qualify; and (4) maintain a registry of the holders of such certificates. NSPE's acceptance of the committee report and subsequent favorable action established ICET.

ICET's Definition of the Engineering Technician

ICET had initially accepted the definition of the term "engineering technician" which the Engineers' Council for Professional

Development published in 1953,[1] but subsequently modified the definition to read as follows:

> An engineering technician is one who, in support of and under the direction of professional engineers or scientists, can carry out in a responsible manner either proven techniques, which are common knowledge among those who are technically expert in a particular technology, or those techniques especially prescribed by professional engineers.
>
> Performance as an engineering technician requires the application of principles, methods and techniques appropriate to a field of technology, combined with practical knowledge of the construction, application, properties, operation, and limitations of engineering systems, processes, structures, machinery, devices, or materials, and, as required, related manual crafts, instrumental, mathematical or graphic skills.
>
> Under professional direction an engineering technician analyzes and solves technological problems, prepares formal reports on experiments, tests and other similar projects or carries out functions such as drafting, surveying, technical sales, advising consumers, technical writing, teaching or training. An engineering technician need not have an education equivalent in type, scope, and rigor to that required of an engineer; however, he must have a more theoretical education with greater mathematical depth and experience over a broader field than is required of skilled craftsmen who often work under his supervision.[2]

ICET distributes this definition widely, including it in both internal documents and published literature.[3]

ICET's Operations

ICET is organized as a Board of Trustees of eight members, four professional engineers and four senior engineering technicians. Board members, who are unpaid, serve staggered, four-year terms; one engineer and one technician are replaced each year. ICET has a full-time executive secretary, Bernard Riggs, who has served in that capacity since October 1965.

ICET is a certifying and examining body only. It is not a licensing body; unlike state registration boards for professional engineers, which have legal status, ICET has no similar authority provided by statute. Nor is ICET a society offering membership to individuals or groups; however, a technician who has received certification may join the American Society of Certified Engineering

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[1]Engineers' Council for Professional Development. "Report of Recognition Committee," *ECPD 21st Annual Report*. (New York: The Council, 1953), p.17.

[2]Institute for the Certification of Engineering Technicians, "Minutes of the Board of Trustees", January 1966.

[3]See, for example, Kenneth C. Briegel, "Certification of Engineering Technicians," *Journal of Engineering Education,* Nov. 1966, p.190.

Technicians (ASCET) in much the same manner as a registered professional engineer may affiliate with NSPE.

ICET has established three grades of certification: Associate engineering technician,[1] engineering technician, and senior engineering technician. Table 71 summarizes the criteria for certification for each of these grades. In applying these criteria, the ICET Board accepts endorsements from persons with B.S. degrees in engineering or science and from certain other supervisors. The Board may also waive the requirement of an examination.

An individual wishing to become certified in one of the three grades submits an application, pays a $10 fee, and arranges for endorsements to be forwarded to ICET. In his application, he supplies personal information and a detailed summary of his work assignments including the degree of responsibility involved in his work. The Board carefully reviews the applicant's statement and those of the references, approving certification if all requirements are met and evidence of progressive personal advancement appears. In cases of doubt, the Board may either reject the application, offer an opportunity for examination, or offer certification in a lower grade. It is the Board's policy to uphold the established standards, even though mistakes of rejection of qualified individuals may occur. Effective January 1, 1973, an examination will be mandatory for initial certification in the lower two grades unless the applicant is a graduate of an ECPD-accredited curriculum. Also, effective at the same time, a written paper in lieu of examination will be required of applicants for initial certification as Senior Engineering Technicians.

Technicians certified in one of the lower grades can upgrade their certifications by submitting appropriate evidence to ICET; the fee for upgrading is $5. An annual renewal fee of $3 is charged to keep certification current.

Progress in Certification

Since applications were first accepted, ICET has issued more than 20,000 certificates; number 25,000 is expected to be issued by mid-1971. Table 72 lists the numbers of technicians certified by year for the period during which ICET has existed. Inferences about the

[1]The "associate engineering technician" grade was originally called "junior engineering technician"; the word "associate" replaced "junior" effective January 1, 1971.

TABLE 71.--Minimum Requirements for Certification in Various Engineering Technician Grades.

Grade	Age	Education and/or Experience	Qualifications
Senior Engineering Technician	No maximum, 35 years minimum	(a) Graduation from an ECPD-accredited program in engineering technology plus 15[a] years engineering technician experience under the direction of a professional engineer or equivalent, or (b) 17 years engineering technician experience under the direction of a professional engineer or equivalent.	Demonstrated high qualifications; knowledge of detailed technical character. Responsible performance.
Engineering Technician	No maximum, 25 years minimum	(a) Graduation from an ECPD-accredited program in engineering technology plus 5[b] years engineering technician experience under the direction of a professional engineer or equivalent, or (b) 7 years engineering technician experience under the direction of a professional engineer or equivalent.	Demonstrated technical knowledge plus satisfactory completion of an examination.[c]
Associate Engineering Technician	No maximum No minimum	(a) Graduation from an ECPD-accredited program in engineering technology, or (b) 2 years engineering technician experience under the direction of a professional engineer or equivalent	Elementary technical ability. Endorsement from one professional engineer or equivalent.

[a]13 years if graduated from an ECPD-accredited baccalaureate engineering technology program.

[b]3 years, if graduated from an ECPD-accredited baccalaureate engineering technology program.

[c]May be waived at the discretion of the Board.

TABLE 72.--Number of Certified Engineering Technicians by Grade and Year, 1964-1971[a].

Year[b]	Technicians With Current Certificates			
	Associate[c] Engineering Technician	Engineering Technician	Senior Engineering Technician	Total
1964	462	929	416	1,807
1965	640	1,323	630	2,593
1966	1,820	3,738	2,015	7,570
1967	2,016	4,068	2,227	8,311
1968	2,458	4,858	2,704	10,020
1969	3,758	5,798	3,426	12,982
1970	4,915	6,580	3,879	15,374
1971	6,340	8,610	5,503	20,453

[a]Data supplied by ICET.

[b]Reporting data is not the same from year to year; caution must be used in drawing inferences about certification rates.

[c]"Junior," prior to 1971.

level of ICET's certification activity can be drawn from the data in this table. Table 73 lists the distribution of certificate holders by state (all grades combined) as of May 1971. Table 74 shows the progress in certification by state, listing the number of certified technicians of all grades by state and by year.

As may be noticed in Tables 72 and 74, the total number of individuals with active certificates has increased rapidly in the last years. One factor which perhaps has contributed substantially to this trend has been the support given to ICET's certification effort by institutions having engineering technology curricula accredited by ECPD. By arrangement with ICET, graduates of such curricula may be certified as Associate Engineering Technicians at the time of graduation. Many recent graduates have received dual credentials at their graduation exercises; this is a practice expected to continue and increase. A second factor which will encourage certification is the growing trend of employers to recognize and support the activity. Some firms pay the certification fee; some give bonuses upon certification; and

TABLE 73.--Distribution by State of Certified Engineering Technicians as of May 1, 1971.

State	Number	State	Number
Alabama	122	Montana	108
Alaska	59	Nebraska	266
Arizona	331	Nevada	52
Arkansas	305	New Hampshire	83
California	661	New Jersey	274
Canal Zone	7	New Mexico	182
Colorado	209	New York	931
Connecticut	502	North Carolina	343
Delaware	148	North Dakota	90
D.C.	26	Ohio	1,453
Florida	477	Oklahoma	501
Georgia	283	Oregon	357
Hawaii	29	Pennsylvania	1,075
Idaho	59	Puerto Rico	21
Illinois	1,079	Rhode Island	65
Indiana	269	South Carolina	149
Iowa	580	South Dakota	28
Kansas	944	Tennessee	587
Kentucky	193	Texas	2,658
Louisiana	215	Utah	20
Maine	78	Vermont	96
Maryland	345	Virginia	534
Massachusetts	457	Washington	383
Michigan	578	West Virginia	134
Minnesota	556	Wisconsin	374
Mississippi	178	Wyoming	18
Missouri	875	Outside the U.S.	106

others base promotions upon the possession of appropriate certificates. The Engineering Division of 3M of St. Paul, Minnesota, the Westinghouse Electric Company of Lima, Ohio, the Marley Company of Kansas City, Missouri, and the firm of Consoer, Townsend and Associates, Chicago, Illinois, are but a few examples of such employers. ICET anticipates a continued heavy workload in the years ahead.

Some Characteristics of Certified Engineering Technicians

Civil engineering technicians form proportionately the largest group certified by ICET at this time. Most of these technicians are employed by state highway departments or are in some manner concerned with road construction projects of federal or state government. Electronics technicians constitute the second largest group.

When ICET initially began its certification procedures, approximately half of the engineering technicians certified were in the

TABLE 74.--Distribution of Certified Engineering Technicians by State for Selected Years, 1963-1971.

STATE	Number of Certified Engineering Technicians, by Year				
	1963	1965[a]	1967	1969	1971
Alabama	8	11	46	82	122
Alaska	2	4	23	43	59
Arizona	6	12	9[illegible]	149	331
Arkansas	3	8	85	244	305
California	51	96	303	422	661
Canal Zone	1	1	3	9	7
Colorado	5	10	81	129	209
Connecticut	15	35	126	255	502
Delaware	54	107	115	142	148
D.C.	4	17	13	12	26
Florida	26	77	230	319	477
Georgia	13	24	80	120	283
Hawaii	0	0	4	9	29
Idaho	4	7	20	37	59
Illinois	58	126	504	736	1,079
Indiana	17	36	105	159	269
Iowa	16	42	169	320	580
Kansas	15	45	512	751	944
Kentucky	6	12	65	111	193
Louisiana	10	27	62	108	215
Maine	1	9	18	38	78
Maryland	14	37	118	159	345
Massachusetts	38	50	140	191	457
Michigan	35	69	264	375	578
Minnesota	24	35	176	349	556
Mississippi	7	15	44	97	178
Missouri	41	113	441	682	875
Montana	4	9	54	109	108
Nebraska	11	31	90	165	266
Nevada	3	3	17	25	52
New Hampshire	5	8	17	49	83
New Jersey	24	38	123	177	274
New Mexico	21	37	94	138	182
New York	137	217	464	659	931
North Carolina	15	46	172	215	343
North Dakota	3	4	11	45	90
Ohio	130	267	805	805	1,453
Oklahoma	29	45	144	144	501
Oregon	8	29	137	137	357
Pennsylvania	135	220	489	489	1,075
Puerto Rico	1	2	8	8	21
Rhode Island	2	6	16	16	65
South Carolina	13	23	56	56	149
South Dakota	2	4	8	8	28
Tennessee	20	47	233	233	587
Texas	104	256	861	861	2,658
Utah	2	3	6	6	20
Vermont	3	3	17	17	96
Virginia	24	60	169	169	534
Washington	[illegible]	114	197	197	383
West Virginia	20	37	79	79	134
Wisconsin	37	54	166	166	374
Wyoming	1	1	9	9	18
Outside the U.S.	1	2	38	38	106
TOTAL	1,473	2,593	8,311	12,982	20,453

[a]Data collected at end of 1964

"engineering technician" (middle) grade, with about one-quarter in the "junior engineering technician" (now, "associate") grade and one-quarter in the "senior engineering technician" grade. Currently, however, the greatest activity appears to be in the associate engineering technician grade, and most of the applicants seem to be recent graduates of schools with one or more ECPD-accredited curricula. Some applicants for certification are graduates of community colleges and use the examination route to certification.

Women form a very small percentage of the total number of certified engineering technicians. It is estimated that only 150-200 women are included in the total of nearly 25,000 individuals who have received certificates.

At the present time, few graduates of baccalaureate programs are included among the engineering technicians certified. ICET anticipates some problems if appreciable numbers of such individuals apply.

Benefits of Certification

Certification of engineering technicians appears to provide a number of benefits. Primarily, it adds status and prestige to the job. Certification also provides, with many employers, a basis for promotion of technicians. Furthermore, certification should clarify the distinctions between the role of the engineer and that of the technician, hopefully resulting in better utilization of this Nation's total supply of technological manpower. Finally, the formal identification of technicians by certification and the communication among technicians which has resulted from the formation of ASCET and the various local sections of this society, can only serve to enhance the position of individuals and improve the performance standards of engineering technicians in general.

CHAPTER 10

A STATISTICAL MODEL FOR ENGINEERING TECHNOLOGY EDUCATION IN THE UNITED STATES

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A STATISTICAL MODEL FOR ENGINEERING TECHNOLOGY EDUCATION IN THE UNITED STATES

This paper[1] presents a statistical model for engineering technology education in the United States. Assumptions are made about future manpower needs and then projections are made of the educational efforts required to meet these needs. Finally, the projected statistics in the model are compared to currently reported statistics in order to assess, tentatively, the national progress in engineering technology education.

Introduction

All recent projections related to future national manpower needs indicate enhanced demands for scientific and engineering technicians.[2] These projections reiterate and reinforce the experience of the past. Engineering technicians, especially individuals with associate or higher degrees, have been in somewhat short supply for the past two decades; in 1968, for example, 48 percent of the employers responding to a survey by the Engineering Manpower Commission reported "shortfalls" in meeting their employment goals for engineering technicians, some by as much as half of their goals.[3] However, there are indications that the gap between demand and supply is closing slightly.[4] For example, an improved enrollment trend is noted in some--although not all--of the institutions which offer educational programs in

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[1]It is emphasized that this document is merely a position paper with the views of its author. Endorsement by the American Society for Engineering Education or the Advisory Committee for ASEE's Engineering Technology Education Study is in no way implied. The content is entirely the responsibility of the author.

[2]For example, see U.S. Department of Labor, *Manpower Report of the President: A Report on Manpower Requirements, Resources, Utilization, and Training* (Washington: U.S. Government Printing Office, 1970); p. 167ff., and U.S. Department of Labor, *Tomorrow's Manpower Needs*, Vol. 3 (Washington: U.S. Government Printing Office, 1969).

[3]Engineers Joint Council, Engineering Manpower Commission, *Demand for Engineers and Technicians, 1968* (New York: The Council, 1969), pp.26-29.

[4]U.S. Department of Labor, Bureau of Labor Statistics, *Technician Manpower: 1966-80*, Bulletin 1639 (Washington: U.S. Government Printing Office, 1970).

this area. But it is believed that a continued higher education effort, in expanding existing programs, inaugurating new programs, and providing faculty members and facilities, will be necessary if these initial trends are to be firmed and real progress made.

In a preliminary effort to assess the educational effort required to meet the nation's needs for engineering technicians, an idealized, statistical model for engineering technology education in the United States has been constructed. The model attempts to match manpower needs with supply and to estimate, in terms of enrollments and graduates, the educational effort in engineering technology needed in each state. The model and the assumptions on which it is based are discussed in the following paragraphs.

Manpower Needs

Various projection strategies have been employed to estimate needs for engineering technicians, but most techniques involve (1) projecting future needs for engineers and scientists on the basis of historical and trend data in an industry-by-industry classification, (2) computing the ratio of technicians to scientists and engineers for each major industry sector (this ratio currently has a mean value of 0.63), and (3) applying these ratios, corrected for trends in technician utilization, to the appropriate projection of scientific and engineering manpower to yeild technician manpower requirements. Some of the results are shown in Table 75. The sources of the first

TABLE 75.--Projections of Needs for Engineering Technicians, 1970-80, Various Sources.

Projection	Projected Annual Need
A	64,600
B	41,000
C	25,400
D	50,200
E	46,500
F	28,400
G	33,000[a]

[a]This figure has been adopted for construction of the model; see discussion in text.

six of these estimates are given below along with a discussion of them.

Projection A

Source: Leonard A. Lecht, *Manpower Needs for National Goals in the 1970's*. New York: Frederick A. Praeger, 1969.

This source listed the following estimated annual job openings, 1966-1975, for technician fields:

Electrical and Electronic	34,400
Other Engineering	7,100
Draftsmen and Designers	23,100
Life Sciences	14,300
Chemical	11,600
Physics	2,100
Other Physical Science	7,200
Mathematics	1,200
Computer and Other	13,000

Assuming that the first three entries in this list constitute the engineering technologies, the total estimated annual need is thus 64,600. While these projections were made to 1975 only and were based on 1966 levels of employment, it seems reasonable that the same estimates would be as valid at the end of the 1970-80 decade as at its beginning. The estimate was predicted on what the author termed a "lower limit for employment opportunities" based on "national priorities" which reflect "more of the same" as existed in the 1960's The author also projected a "higher priority alternative characterized by bolder specific objectives," such as housing starts or massive efforts in pollution control, which led to an even higher estimate of the annual job opening for technicians; the "higher priority" estimate was for approximately 87,000 vacancies per year.

Projection B

Source: John D. Alden, "Engineering Job Prospects for 1970," in *Supply, Demand and Utilization of Scientists and Engineers*, Scientific Manpower Commission and Engineering Manpower Commission, Washington: The Commissions, 1970.

The author cites an estimated average of 65,000 job openings per year for engineers for the next decade (see p.5), influenced but slightly by short-term tightening of the job market. "Irreversible factors in our technological society," a backlog of unfilled jobs, changes in the draft laws, and adjustments of immigration quotas are listed as arguments why annual manpower needs for engineers will not go below the 65,000 level. Since the same author, in other Engineering Manpower Commission publications, has stated the ratio of technicians to engineers nationally to be .63 to 1, the implication is that .63 x 65,000=41,000 technician jobs will be available annually.

Projection C

Source: U.S. Department of Labor, *Technician Manpower, 1966-80*, Bulletin No. 1639, Bureau of Labor Statistics. Washington: U.S. Government Printing Office, 1970. (Adapted.)

The Bureau of Labor Statistics has listed estimates of the number of technicians of various categories employed in 1966 and projected requirements in 1980 as shown in Table 76. Computations based on these data lead to the results shown in Table 77. In making these computations, it was assumed (1) that at least 50 percent of the draftsmen needed in 1980 should have associate or higher degrees, (2) that all engineering technicians should have associate or higher degrees, and (3) that the "other" category (which included

TABLE 76.--Employment of Technicians by Occupational Specialty, Estimated 1966 and Projected 1980 Requirements.

Occupation	1966 Employment	1980 Requirements
Draftsmen	272,300	434,300
Engineering Technicians	299,200	453,800
Other Technicians	125,100	205,800

TABLE 77.--Projections of Increases in Needs for Technicians with Associate or Higher Degrees, 1966-1980.

Occupation	Employment Increases 1966-1980	Number Requiring Associate or Higher Degrees
Draftsmen	162,000	81,000
Engineering Technicians	154,600	154,600
Other Technicians	80,700	20,000
TOTAL		225,600

computer programmers and mechanics, industrial designers, and surveyors) consisted 25 percent of individuals who would be of the engineering technician type and hence need associate or higher degrees.

In addition to *new* job openings, a number of *replacements* to the 1966 work force were believed necessary to compensate for losses from the field due to death, retirement or transfers to other occupations. Attrition rates of 20 percent were assumed for employees already in the field in 1966, 15 percent for those who entered it during the 1966-1980 period. With further assumptions that replacements for one-half the replaced draftsmen, all the replaced engineering technicians, and one-fourth of the replaced "other" technicians should be college-trained, estimates of replacement needs were calculated as shown in Table 78.

The total needs, new vacancies (225,600) plus replacements (127,200), are for 352,800 college-trained technicians in the period 1966-1980, since this period covers a 14 year span, the average annual need is computed to be about 25,200 technicians.

TABLE 78.--Projections of "Replacement" Openings for Technicians, 1966-1980.

Occupation	Number in Field	Attrition Rate	Number Replaced	Number of College-Trained Replacements
Draftsmen, 1966	272,300	.20	54,460	27,200
Engineering Technicians, 1966	299,200	.20	60,000	60,000
Other Technicians, 1966	125,100	.20	25,020	6,200
All New Entrants, 1966-1980	225,600	.15	33,800	33,800
TOTAL				127,200

Projection D.

Source: Same as Projection C.

An alternative to the somewhat involved computations of Projection C is to consider all "Natural Science and Engineering Technicians", except Life Science Technicians, as a single category. A simplified calculation then exists, as follows:

1. Number of technicians employed in 1966 816,900
2. Number of new jobs, 1966-1980 469,900
3. Replacements for 20 percent of line 1 163,400
4. Replacements for 15 percent of line 2 70,500
5. Total 1966-80 Needs (sum of lines 2,3,4) 703,800
6. Average annual need (line 5 divided by 14) 50,200

The result, 50,200 technicians per year, is a total employment need, including technicians to be upgraded from various sources as well as those who have graduated from collegiate pre-employment preparatory programs. While this estimate is considerably higher than that of Projection C, it is somewhat comparable to the supply which employers state they believe to be desirable in order to eliminate the necessity for extensive on-the-job training and heavy reliance on upgrading.

Projection E

Source: U.S. Department of Labor, *Manpower Report of the President: A Report on Manpower Requirements, Resources, Utilization, and Training*. Transmitted to Congress, March 1970. Washington: U.S. Government Printing Office, 1970.

The President's Report cites employment requirements for engineering science technicians as growing at about 35-40 percent in the 1968-1980 period (chart 21, p. 163); it states that "on the average, about 74,000 new engineers would be needed annually during the 1968-80 period to make possible the projected employment growth and replace those who die, retire or transfer to other fields of work" (p.169). Assuming a technician-to-engineer ratio of .63, 74,000 engineers implies about 46,500 technicians.

Projection F

Source: Same as Projection E.

With some caution, the President's Report also suggests that the nation's manpower needs for engineers can be met by 45,000 engineering *graduates* yearly (as contrasted to the 74,000 *total engineers* used in Projection E). The implications, assuming the validity of the .63 ratio used previously, is that 28,400 engineering technology *graduates* will be adequate to supply manpower needs. In the cases of both engineers and technicians, the assumption is that individuals often enter these fields without having completed the formal schooling generally associated with these occupations and that the numbers of such "drop-ins" are sufficiently great to reduce the manpower requirements for graduates.

Some of the estimates of manpower needs for technicians as shown in Table 75, notably projections "A" and "D", appear unrealistically high. The "A" projection was based on the assumption that high priorities would be placed during the coming decade on the achievement of substantial national technological goals, such as an accelerated program of space exploration or a major attack on urban problems; it seems unlikely, however, that such priorities will develop at a pace sufficient to create the manpower needs suggested. Projection "D" is probably also somewhat high, since it assumes federal spending in aerospace and defense-related activities at a higher level than now prevails, and does not account for the effect on scientific and technical manpower demand caused by reduced federal budgets. The economic and employment conditions of late 1969, 1970, and early 1971 appear to repudiate both of these projections.

Conversely, some of the lower projections may have underestimated new or changed employment needs being created as a result of the evolution of a general technical environment which is increasingly sophisticated and complex; it is believed that this is probably true of projection "C" in Table 75.

It is believed, therefore, that during the 1970's the manpower needs for college-trained technicians will exceed 25,000 graduates per year, but will not reach 50,000 per year. *An estimate of 33,000 graduates per year, with at least an associate degree, has been adopted for this model;* in support of this estimate, the following observations are made:

1. Just before the start of the decade, approximately 20,000 individuals were graduated annually from associate degree engineering technology programs. Employers were reporting "shortfalls" in hiring goals which averaged 20 percent. Hence, it is perhaps reasonable to estimate that the need then was for approximately 24,000 graduates. Needs, in terms of new jobs, are expected to increase during the 1970's by about 40 percent; hence annual needs may be expected to grow from 24,000 to about *33,600*.

2. The total technical manpower pool--including high-school graduates and drop-outs, college graduates and drop-outs, individuals completing educational programs leading to awards less than associate degrees, apprentices, veterans whose military experience included technical training, and other incidental sources--was approximately 70,000 technicians per year in 1970. This total figure will probably not grow appreciably by 1980. However, less than 30 percent of the technicians entering employment in 1970 were "college-trained," the largest fraction being industry-trained in on-the-job programs. It has been suggested that if the proportion who has completed collegiate pre-employment curricula could be increased to 50 percent, then the existing manpower pool would be adequate to meet the nations needs. The implication is that an average of *35,000* college-trained technicians will be needed annually.

3. Projections exist that an average of 43,000 engineering college graduates will be produced during the 1970's, with about 80,000 first-time students enrolling annually; a retention rate of 54 percent.

Historically, first-time technical enrollments has been .7 as large as engineering enrollments, and might thus be expected to be around 56,000; if the same retention rate (54 percent) were achieved, one could predict that about *30,000* technology graduates per year could be produced.

4. Short-range enrollment trends are sharply up in certain technology specialties. If these trends continue, and attrition rates are slightly reduced, it is feasible that the trends in these specialties will offset continuing steady declines in others, so that net enrollments near 120,000 can be maintained. It is feasible, therefore--again following historical trends--that about 25-30 percent of the total enrollment will graduate each year, that is, about *30,000* to *36,000* graduates seem potentially available.

5. The best match between the nation's projected needs for graduate technicians and the number of individuals feasibly available to meet those needs apparently occurs in the range 30,000 - 36,000. Hence, a projection of *33,000* is taken as a working estimate.

There are few projections of the manpower needs for technicians with bachelor's degrees, i.e., technologists. One study led to an estimate that a minimum of 20 percent of all technicians should possess bachelor's or higher degrees.[1] It is believed, however that this projection is low. Trends, now that a small but growing supply of baccalaureate graduates have appeared, suggest that increasing numbers of employment opportunities will exist for such individuals and that as many as 10,000 to 12,000 positions per year--approximately one-third of the projected "college-trained technician" group--will be available during the 1970's. The model has assumed an average need for approximately 11,000 baccalaureate graduates per year.

Sources of Students

The individuals who will enter the labor market as technicians during the 1970's or prepare to do so have already been born; they are, in fact, already in the educational stream, at least in the upper elementary grades, and some are already in college. Although there are some possibilities for small shifts in students' interest patterns in the future, it is likely that the number of students available in the next decade for education as technicians is a relatively fixed quantity, subject to only minor short-term variation.

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[1]Eckhart A. Jacobsen, *A Survey of Technical Needs for Industry and Implications for Curriculum Development in Higher Education*, Cooperative Research Project with U.S. Office of Education, 1966.

It is possible to estimate the pool from which students for engineering technology will be drawn. The U.S. Office of Education, for example, has projected future "freshmen" or "first-time degree credit" college enrollment as follows:[1]

Year	Freshman Enrollment
1970	1,661,000
1973	1,889,000
1977	2,127,000

Preliminary counts for 1970 suggest that actual enrollments may exceed the projections slightly, so that it is reasonable to assume that freshman enrollments during the period 1970-80 will average about 2,000,000 students. The number of males is expected to exceed slightly the number of females, so that an average of about 1,100,000 men per year will enter college. In the past, about 15 percent of college men have chosen technological fields (physical science, mathematics, engineering, technology, etc.)[2] If this ratio remains sensibly constant during the next decade, then approximately 165,000 men will constitute the annual pool from which engineering technology students can be drawn. If past trends continue, the largest fraction of these 165,000 will select mathematics, physical science or engineering as disciplines, with a smaller proportion, perhaps 30-40 percent, choosing engineering technology or related fields. The number of entering students per year could vary from 49,500 (30 percent) to 66,000 (40 percent). Some indications exist that the latter figure is the more realistic. Recent follow-up studies[3] of high school graduates suggest that 2 percent of these graduates enter technician education programs. Since the average number of high school graduates per year during the decade 1970-1980 is expected to be about 3,330,000,[4] some 66,000 students can be projected to enroll in engineering technology programs if the 2 percent trend continues.

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[1]U.S. Office of Education, National Center for Educational Statistics, *Projections of Educational Statistics to 1977-78* (Washington: U.S. Government Printing Office, 1969), Table 5, p.13.

[2]*Ibid.*, Table 19, p.32.

[3]John C. Flanagan and others, *Project TALENT One-Year Follow-up Studies* (Pittsburg: Project TALENT Office, University of Pittsburg, 1966).

[4]U.S. Office of Education, *op.cit.*, Table 17, p.20.

Attrition, Completions, Advanced Study

Historically, the over-all attrition rates in technology programs have been excessively large. It is not unusual for 60 percent of an entering class to drop-out, change majors, or in some other way fail to graduate. Despite these historical data, however, an optimistic outlook has been taken, and attrition rates of only 50 percent have been assumed for this model.[1] In most cases, the majority of attrition appears to occur in the first year; two out of three who eventually leave the field have done so before the beginning of their sophomore year. In light of these trends, it appears reasonable to assume an academic progression in which sophomore enrollments are approximately 65 percent of freshmen enrollments and associate degree graduates are 50 percent of freshmen enrollments.

There have always been some graduates of associate degree engineering technology programs who have continued in college to study for baccalaureate degrees: some have pursued engineering programs; some, business administration; some, education; and the remainder have studied in miscellaneous other areas. Often these students "lost" credits. The emergence of baccalaureate programs in engineering technology, however, has provided for many associate degree graduates opportunities for further study without such loss of credit and appears to be one factor, along with mounting social pressures, which has recently greatly increased the number of associate degree graduates who continue their schooling. A recent survey revealed that 32 percent of students in associate degree programs planned to seek a baccalaureate degree.[2] At some institutions, the proportion to seek the higher degree has been reported to be as high as 80 percent. Reasonable estimates for the future appear to be that about 40 percent of associate degree graduates will seek bachelor's degrees and that 85 percent of these (approximately one-third of the associate degree graduates) will attain their goals. These estimates have been adopted for the purposes of the model.

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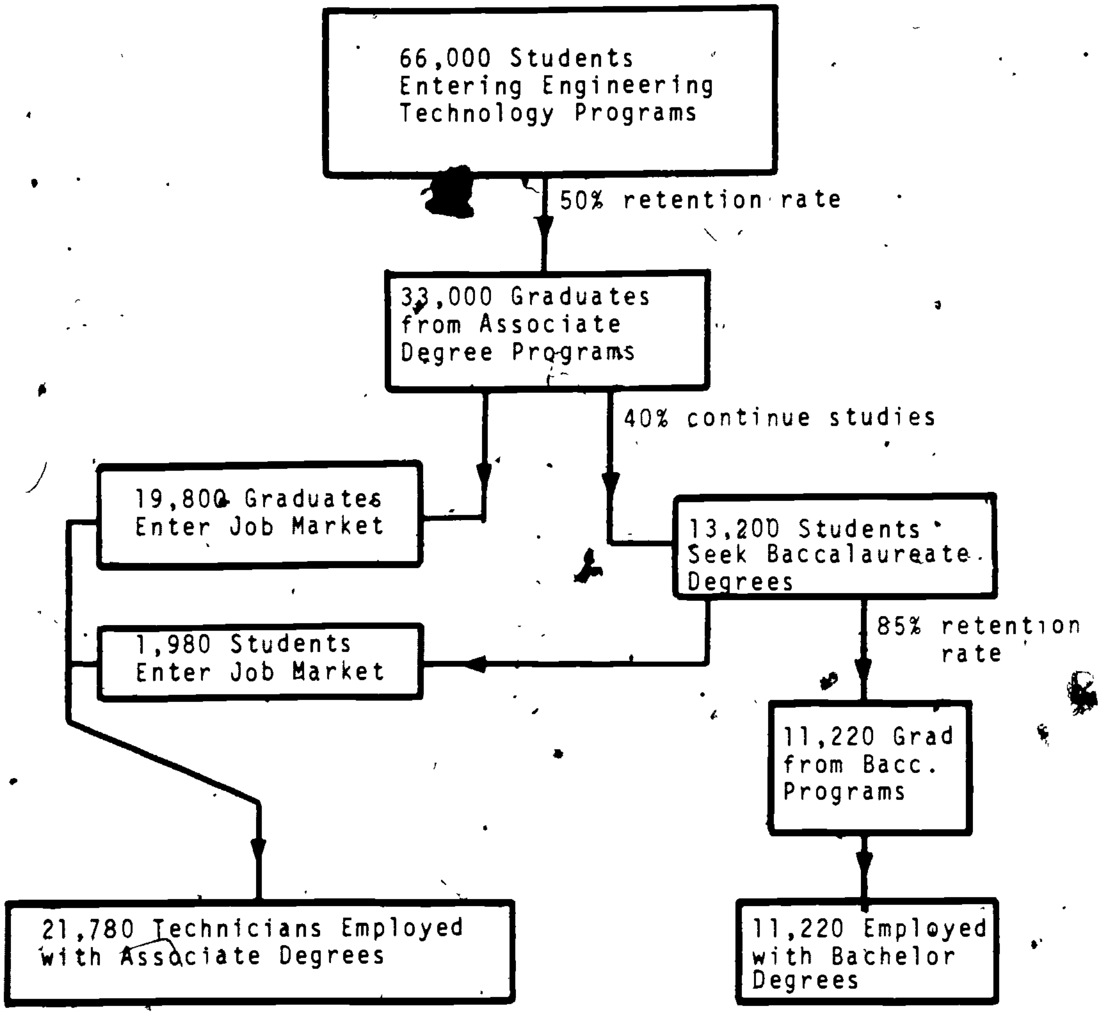
[1]An attrition rate of 50 percent actually represents a substantially higher retention rate than that which most institutions report; many observers feel that it is almost essential, from the standpoints of meeting manpower needs and providing adequate educational opportunity, that institutions immediately develop positive programs to assure that retention rates are increased to or beyond the 50 percent level.

[2]American Society for Engineering Education, *Student Technicians: A Study of Some Characteristics of Students Enrolled in Associate Degree Engineering Technology Programs*, Study Report No. 7, Engineering Technology Education Study (Washington: ASEE, 1970). See also Chapter 7, herein.

FIGURE 21.--A Statistical Model for Engineering Technology Education in the United States.



The Macroscopic Model

The statistical model for engineering technology education in the United States as a whole, that is, the *macroscopic* model, is based on the following assumptions, the rationales for which have been given above:

1. 66,000 students will enter engineering technology programs each year.
2. 50 percent (33,000) of these will graduate with associate degrees.
3. 40 percent (13,200) of the associate degree graduates will continue studies toward a baccalaureate degree, and 60 percent (19,800) will enter the labor force as technicians.

4. 85 percent (11,220) of those who seek baccalaureate degrees will attain them; the remainder (1,980) will join the labor force as technicians.

5. The labor force, when the cycle is fully established, will be augmented annually by 11,220 baccalaureate graduates and 21,780 (19,800 plus 1,980) associate degree graduates; this supply will balance the projected annual need for 33,000 "college trained" technicians and will provide individuals with bachelor's degrees in a proportion deemed desirable.

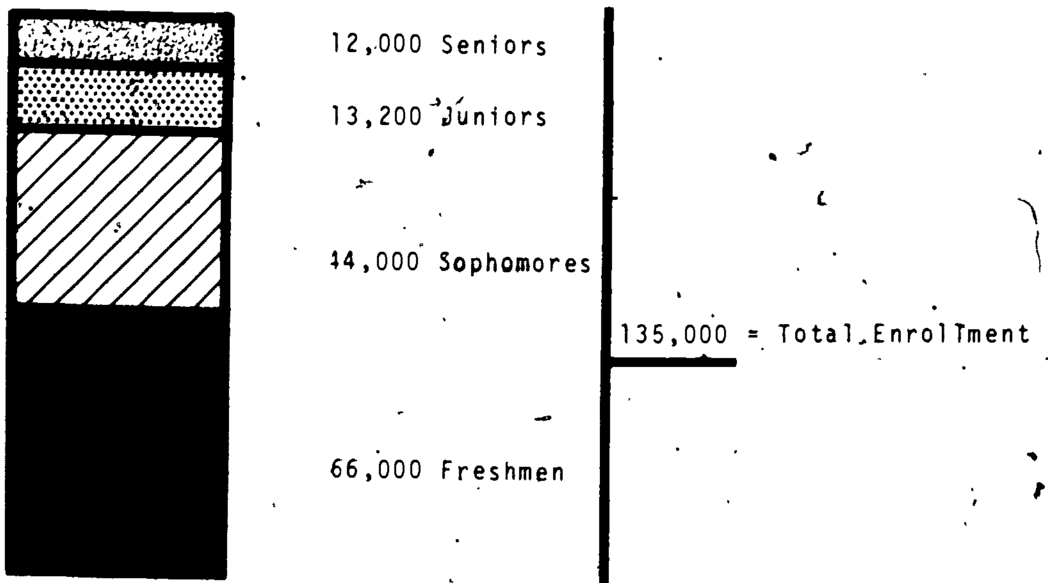
The model is illustrated in Figure 21.

This model has implications for the enrollment of engineering technology students in institutions of higher education, as follows:

1. 66,000 students will enroll as freshmen, although about one-third of these will not be retained past the first year.
2. About 44,000 students will enroll as sophomores.
3. Approximately 110,000 students will be enrolled in associate degree programs (or the lower division of baccalaureate programs) in engineering technology.
4. 13,200 students will transfer (or continue) to the junior year, although about 10 percent of these will not be retained past this year.
5. About 12,000 students will enroll as seniors.
6. Approximately 25,000 students will be enrolled in the upper division of baccalaureate engineering technology programs.
7. The total enrollment in all engineering technology programs will be approximately 135,000 students.

Figure 22 illustrates graphically the enrollment distribution just discussed.

FIGURE 22.--Projected Enrollments of Students in Engineering Technology Programs, According to a Statistical Model



Constructing a Detailed Model

It is possible to identify a number of philosophical bases on which a detailed, or state-by-state, model of engineering technology education can be constructed. Among these are the following: (1) the provision of equally accessible educational opportunity, (2) adequately meeting the technical manpower needs of the employers in a local community, and (3) fully utilizing existing resources, wherever located, in order to minimize outlays for higher education. These are all attractive, viable concepts; they each would lead, however, to slightly differing models. The factors and the judgments made on their relative priorities are discussed in the paragraphs following:

Equally Accessible Educational Opportunity

The equality of opportunity for students to attend institutions of higher education and receive instruction in the disciplines of their choice has long been an American goal. This goal has never been fully realized and probably will not be. It is not pragmatic that in every state the institutions of higher education--individually or collectively--offer *every* known discipline; however, groups of states, through interstate or regional compacts, have approached the ideal. On the other hand, for the *ordinary* disciplines--and engineering technology is an important one--enrollment opportunities should exist in every state; furthermore, such opportunities should be commensurate with each state's population. The implication for modeling, then, is that the number of engineering technology students and graduates in a given state should have the same relationship to the national totals of such students and graduates as the population of the state has to the national population. It is believed that this principle is of paramount importance, and has been used for the model which has been constructed.

Meeting Local Manpower Needs

Areas which are heavily industrialized or which have concentrations of scientific and engineering activities generally have per capita needs for technical manpower which are greater than those in areas which are agricultural or which concentrate on office or service occupations. Supplies of technical manpower are necessary both to maintain the industrial/technological establishment where it exists and to insure its growth and expansion. The implication for modeling here is that states with a substantial industrial/technological establishment should provide for relatively more enrollments in engineering technology programs than do states with lesser concentrations of industrial/technological activity; apportionment of enrollments in the model could perhaps be made on the basis of the several states' shares of the GNP, the value of manufactured goods, the number of scientists and engineers employed, or other similar indices. Such a basis, however, has been rejected.

Two major factors were considered in the rejection of "local manpower needs" as the primary basis for modeling a system of engineering technology education. First, contemporary society is highly mobile. Individuals do not necessarily seek employment in the community in which they were educated. Nor does an employer need to rely on local sources of manpower: he can recruit from the nation. Hence, contiguity of educational and employment opportunities appears not to be of primary importance. And secondly, a less disproportionate distribution of industrial/technological activities in the United States seems desirable; since a factor which will tend to influence site-selections by new or expanding industries is the availability of technical manpower, the existence of engineering technology programs in all states, implying manpower availability in all states, seems likely to favor an ultimately more uniform distribution of industries.

Utilizing Existing Resources

Because the costs of higher education have escalated greatly in recent years, and because education is competing for public support with welfare, highways, law enforcement and other social programs of major importance, it has become highly important that states carefully assess the returns from public monies spent and, insofar as possible, optimize cost-benefit ratios. The nature of engineering technology education is inherently such that both its capital and its operating costs are relatively high when compared to most other kinds of education; states must be especially careful in assigning priorities in this area. The implications for modeling are that, to minimize costs, any needed increases in enrollments should be distributed almost entirely to existing facilities and programs, with few new programs provided. This concept, too, is rejected--not because it lacks validity but, rather, because it seems to discount the socially and culturally more important philosophy of service to students, that is, provision of reasonably accessible educational programs to all young people, regardless of their ethnic and socioeconomic backgrounds or the region of the country in which they happen to reside. The existence of engineering technology education opportunities in all states, then, seems a highly desirable goal, one to be sought in spite of cost considerations alone.

The Detailed Model

Table 79 gives a detailed statistical model for engineering technology education. In the table, projections of enrollments and graduates are given, apportioned among the states according to their population as determined in the 1970 census. Footnotes to the table give information about the projection techniques. The column totals for the detailed model are quite comparable to the gross estimates of the macroscopic model given earlier.

Assessment of the Model

A statistical model of the type given here is subject to a variety of weaknesses, but may also have some general virtues. The shortcomings and possible strengths are discussed in the following:

Weaknesses

Population Base.--The individuals who will enter college during the period 1970-80 and who consititue the population pool from which engineering technology students will be drawn are predominantly young people now in the 8-18 age bracket. Individuals in this age bracket are not necessarily uniformly distributed demographically; hence, apportionment of "quotas" of engineering technology students according to total population rather than to the 8-18 year old population group produces some biases. While the model is not extremely sensitive to this factor, it does tend to underestimate quotas in the more populous states and to overestimate them in less populous ones.

Choice by Students.--Some research has indicated that students whose homes are in rural and small town environments choose technology curricula in college relatively more often than do students from urban environments.[1] In this model, no account has been taken of such a proclivity. The bias tends to underestimate the quotas for states in which an appreciable fraction of the population resides in rural areas or small towns.

Retention Rates.--In the model, it has been assumed that the over-all retention rate for students enrolling in engineering technology programs would be 50 percent; this is a fairly optimistic assumption, since retention rates historically have averaged only 40 percent. Unless the retention rate can be raised to a 50 percent level, only about 26,400 graduates, rather than 33,000, would be produced annually, a serious shortfall in meeting manpower needs. For 33,000 graduates to be produced at a 40 percent retention rate, approximately 82,000 freshmen would be needed annually, a level unlikely to be reached.

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[1]See, for example, Chapter 7.

TABLE 79.--Projections of Annual Enrollments in and Graduates from Engineering Technology Education Programs: A Statistical Model.

Political Unit	Population Base (1)	Freshmen (2)	Sophomores (3)	Total Lower Division (4)	Associate Degrees (5)	Juniors (6)	Seniors (7)	Total Upper Division (8)	Bachelor Degrees (9)	Total Enrollments (10)
United States										
From Macroscopic Model	-	66,000	44,000	110,000	33,000	13,200	12,000	25,000	11,220	135,000
Total of Detail	200,295,000	66,000	43,185	109,185	33,000	13,200	11,855	25,055	11,220	134,240
Alabama	3,373,000	1,080	710	1,790	540	220	190	410	187	2,200
Alaska	295,000	100	65	165	50	20	20	40	17	205
Arizona	1,752,000	580	380	960	290	120	105	225	102	1,185
Arkansas	1,886,000	620	410	1,030	310	120	105	225	102	1,255
California	19,715,000	6,520	4,240	10,760	3,260	1,300	1,150	2,450	1,105	13,210
Colorado	2,178,000	720	470	1,190	360	140	125	265	119	1,455
Connecticut	2,991,000	990	650	1,640	495	200	180	380	170	2,020
Delaware	543,000	180	120	300	90	40	35	75	34	375
District of Columbia	746,000	250	170	420	125	50	45	95	42	515
Florida	6,671,000	2,210	1,440	3,650	1,105	440	405	845	374	4,495
Georgia	4,492,000	1,480	980	2,460	740	300	270	570	255	3,030
Hawaii	749,000	250	170	420	125	50	45	95	42	515
Idaho	698,000	230	150	380	115	50	45	95	42	475
Illinois	10,978,000	3,630	2,460	6,090	1,815	720	630	1,350	612	7,440
Indiana	5,143,000	1,690	1,090	2,780	845	340	305	645	289	3,425
Iowa	2,789,000	920	600	1,520	460	180	170	350	153	1,870
Kansas	2,179,000	720	470	1,190	360	140	125	265	119	1,455
Kentucky	3,161,000	1,040	680	1,720	520	210	190	400	179	2,120
Louisiana	3,564,000	1,170	760	1,930	585	230	210	440	196	2,370
Maine	977,000	320	210	530	160	60	55	115	51	645
Maryland	3,875,000	1,270	830	2,100	635	250	225	475	212	2,575
Massachusetts	5,630,000	1,850	1,200	3,050	925	370	340	710	315	3,760
Michigan	8,778,000	2,900	1,880	4,780	1,450	580	520	1,100	494	5,880
Minnesota	3,768,000	1,240	810	2,050	620	250	225	475	212	2,525
Mississippi	2,159,000	710	480	1,190	355	140	125	265	119	1,455
Missouri	4,627,000	1,520	990	2,510	760	300	270	570	255	3,080
Montana	682,000	220	150	370	110	40	35	75	34	445
Nebraska	1,468,000	480	320	800	240	100	90	190	85	990
Nevada	482,000	160	110	270	80	30	25	55	25	325
New Hampshire	723,000	240	170	410	120	50	45	95	42	505
New Jersey	7,093,000	2,330	1,510	3,840	1,165	470	420	890	400	4,730
New Mexico	998,000	330	220	550	165	70	65	135	60	685

Political Unit	Population Base (1)	Freshmen (2)	Sophomores (3)	Total Lower Division (4)	Associate Degrees (5)	Juniors (6)	Seniors (7)	Total Upper Division (8)	Bachelor Degrees (9)	Total Enrollments (10)
New York	18,019,000	5,940	3,850	9,790	2,970	1,190	1,070	2,260	1,012	12,050
North Carolina	4,968,000	1,640	1,070	2,710	820	330	300	630	281	3,340
North Dakota	612,000	200	130	330	100	40	35	75	34	405
Ohio	10,542,000	3,490	2,270	5,760	1,745	700	630	1,330	595	7,090
Oklahoma	2,498,000	820	540	1,360	410	160	150	310	136	1,670
Oregon	2,056,000	680	450	1,130	340	140	125	265	119	1,395
Pennsylvania	11,670,000	3,850	2,500	6,350	1,925	770	690	1,460	655	7,810
Rhode Island	922,000	300	200	500	150	60	55	115	51	615
South Carolina	2,523,000	830	540	1,370	415	170	150	320	145	1,690
South Dakota	657,000	220	150	370	110	40	35	75	34	445
Tennessee	3,839,000	1,260	820	2,080	630	250	225	475	212	2,555
Texas	10,998,000	3,630	2,360	5,990	1,815	730	660	1,390	620	7,380
Utah	1,052,000	350	230	580	175	70	65	135	60	715
Vermont	438,000	140	100	240	70	30	25	55	25	295
Virginia	4,543,000	1,490	980	2,470	745	300	270	570	255	3,040
Washington	3,353,000	1,100	720	1,820	550	220	200	420	187	2,240
West Virginia	1,702,000	560	360	920	280	110	100	210	93	1,130
Wisconsin	4,367,000	1,440	940	2,380	720	290	260	550	246	2,930
Wyoming	329,000	110	80	190	55	20	20	40	17	230

(1) Population figures from PC(P1)-1, *1970 Census of Population*, U.S. Department of Commerce, Bureau of the Census.

(2) $N_2 = N_1 \times (66,000/200,295,000)$, assuming a needed first-enrollment input of 66,000; results rounded to nearest 10.

(3) $N_3 = .65 \times N_2$, rounded to nearest 5; assumed 35 percent attrition rate during freshman year.

(4) $N_4 = N_2 + N_3$.

(5) $N_5 = .5 \times N_2$; assumed overall retention rate of 50 percent.

(6) $N_6 = .4 \times N_5$; assumed 40 percent will continue toward baccalaureate degree.

(7) $N_7 = .9 \times N_6$; rounded to nearest 5; assumed 10 percent attrition rate during junior year.

(8) $N_8 = N_6 + N_7$.

(9) $N_9 = .85 \times N_6$; assumed overall retention rate of 85 percent in upper division programs.

(10) $N_{10} = N_4 + N_8$.

Furthermore, it has been assumed that approximately two-thirds of those who enter as freshmen would enroll as sophomores. The experience of some institutions has been that attrition during the freshman year is greater than assumed here. A greater freshman attrition would imply a smaller sophomore class and smaller total enrollment. Fortunately, estimates here do not affect other data provided the overall retention rate is maintained at 50 percent.

Matching Graduates to Jobs.--A fundamental assumption in the model has been that a national manpower need for 33,000 college-trained engineering technicians could be met by providing 33,000 graduates of engineering technology curricula. Such an assumption may be unrealistic; experience indicates that a certain proportion of college graduates never enter the field for which they prepared. A recent survey of engineering technology students[1] suggested that 14 percent would not seek employment directly related to their education. Although some who responded in such manner were expecting to enter the service and hence were undecided about their future careers, at least 10 percent had definite plans to abandon engineering technology, even though they were successfully completing their programs. If such circumstances are prevalent, then more than 36,000 graduates (72,000 freshmen) will be required annually for 33,000 eventually to reach the job market. The model does not account for graduates leaving the field, and hence may underestimate national enrollment needs.

Estimation of Manpower Needs.--The projection of manpower needs for 33,000 college-trained technicians, used in constructing the model, is subject to the inadequacies of all such projections. It is believed the projection is slightly conservative and underestimates somewhat the increased opportunities for technicians in the future job market. On the other hand, the economic climate at the beginning of this decade is not encouraging, so that a projection of 33,000 technician and technologist jobs--believed conservative--could be an optimistic overestimate instead.

Estimates of Student Sources.--The model has assigned "Quotas" of entering freshmen engineering technology students to each state. A basic assumption is that such quotas can be filled; this may well not be the case. Many young people, for example, who are quite competent and fully capable of completing a technology program appear to be seeking educational programs and careers in social fields rather than in science and technology because the latter currently have

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[1] *Ibid.*

a "bad image." In addition, many others with interest in technical fields have not properly prepared themselves in high school and are deterred from entry into associate degree programs. To the extent that the potential supply of students may not match the projected entering enrollment, the model is weak. No estimates of discrepancies are available.

Strengths

Guidelines for Evaluation.--A special virtue of the model, constructed as it is, is that it provides educators in each state with rough statistical guidelines by which they can evaluate their state's efforts in the engineering technology domain.

Conservatism of Model.--The model is essentially conservative, in that it suggests in only a few cases that statewide efforts be drastically increased. It sets educational goals which can reasonably be reached. Furthermore, there seems small likelihood that this model will produce an *oversupply* of technicians. Most of the assumptions made (e.g., attrition rates, graduates leaving the field, etc.) were weighted toward enhancing the manpower supply; if these assumptions are invalid, a lesser supply of college-trained technicians will be available, resulting in a manpower deficit rather than a surplus of highly educated but unemployed technical workers.

Matching Social Aspirations.--The model, in using both associate and baccalaureate degree graduates to satisfy projected manpower needs for "college-trained" technicians, has completely abandoned the concept of "terminal" education; it assumes the existence of avenues to engineering technology students for upward mobility, both to fulfill personal aspirations and to respond to parental, peer group and other societal pressures. Such avenues are believed essential in the educational system.

Assessment of Contemporary Progress

An initial, tentative assessment of contemporary progress in engineering technology education may be made by comparing available data on enrollments and graduates with the corresponding projections in the model. Tables 80 and 81 are illustrations of how such an assessment can be made. These tables contain relevant statistics, state-by-state, along with a symbol to indicate roughly how each state "conforms" to the model.

Extreme caution must be observed in interpreting Tables 80 and 81 or drawing inferences from them; these tables are illustrations only. Unfortunately, authoritative and reliable data are not avail-

TABLE 80.--Comparison of Modeled and Actual Values of Lower Division Enrollments and Associate Degree Graduates in Engineering Technology Programs

Political Unit	Enrollments			Graduates		
	Projected[a]	Actual[b]	Conformity[c]	Projected[a]	Actual[b]	Conformity[c]
TOTAL U.S.	109,185	96,526	-	33,000	24,311	-
Alabama	1,790	243	-	540	63	-
Alaska	165	121	-	50	9	-
Arizona	960	2,078	+	290	344	+
Arkansas	1,030	201	-	310	55	-
California	10,760	10,336		3,260	2,582	-
Colorado	1,190	924	-	360	272	-
Connecticut	1,640	2,346	+	495	641	+
Delaware	300	133	-	90	28	-
District of Columbia	420	385		125	106	-
Florida	3,650	4,068		1,105	798	-
Georgia	2,460	979	-	740	276	-
Hawaii	420	104	-	125	28	-
Idaho	380	213	-	115	59	-
Illinois	6,090	3,172	-	1,815	917	-
Indiana	2,780	4,088	+	845	1,111	+
Iowa	1,520	1,453		460	414	
Kansas	1,190	579	-	360	137	-
Kentucky	1,720	251	-	520	36	-
Louisiana	1,930	295	-	585	81	-
Maine	530	354	-	160	117	-
Maryland	2,100	975	-	635	230	-
Massachusetts	3,050	5,230	+	925	1,745	+
Michigan	4,780	3,920	-	1,450	944	-
Minnesota	2,050	430	-	620	96	-
Mississippi	1,190	480	-	355	128	-
Missouri	2,510	1,595	-	760	391	-
Montana	370	126	-	110	34	-
Nebraska	800	1,380	+	240	677	+
Nevada	270	81	-	80	20	-
New Hampshire	410	624	+	120	178	+
New Jersey	3,840	839	-	1,165	206	-
New Mexico	550	450	-	165	171	

Political Unit	Enrollments			Graduates		
	Projected[a]	Actual[b]	Conformity[c]	Projected[a]	Actual[b]	Conformity[c]
New York	9,790	13,886	+	2,970	3,195	
North Carolina	2,710	2,551		820	664	-
North Dakota	330	788	+	100	203	+
Ohio	5,760	5,964		1,745	1,464	-
Oklahoma	1,360	1,957	+	410	323	-
Oregon	1,130	3,098	+	340	515	+
Pennsylvania	6,350	4,980	-	1,925	1,421	-
Rhode Island	500	240	-	150	65	-
South Carolina	1,370	1,344		415	356	-
South Dakota	370	258	-	110	37	-
Tennessee	2,080	639	-	630	116	-
Texas	5,990	2,804	-	1,815	678	-
Utah	580	956	+	175	234	+
Vermont	240	349	+	70	126	+
Virginia	2,470	1,550	-	745	356	-
Washington	1,820	2,332	+	550	420	-
West Virginia	920	614	-	280	153	-
Wisconsin	2,380	3,552	+	720	958	+
Wyoming	190	211		55	54	

[a]Data from Table 79.

[b]Data estimated in many cases; see Appendix G.

[c]Apparent surpluses (+) or deficits (-) of actual values when compared to model; no entry indicates reasonable conformity to model.

TABLE 81.--Comparison of Modeled and Actual Values of Upper Division Enrollments and Baccalaureate Degree Graduates in Engineering Technology Programs.

Political Unit	Enrollments			Graduates		
	Projected[a]	Actual[b]	Conformity[c]	Projected[a]	Actual[b]	Conformity[c]
Total U.S.	25,055	20,132	-	11,220	5,084	-
Alabama	410	280	-	187	58	-
Alaska	40	0	-	17	0	-
Arizona	225	743	+	102	186	+
Arkansas	225	8	-	102	2	-
California	2,450	1,276	-	1,105	344	-
Colorado	265	326	+	119	79	-
Connecticut	380	0	-	170	0	-
Delaware	75	0	-	34	0	-
D.C.	95	0	-	42	0	-
Florida	845	81	-	374	13	-
Georgia	570	493	-	255	55	-
Hawaii	95	64	-	42	16	-
Idaho	95	0	-	42	0	-
Illinois	1,350	2,192	+	612	470	-
Indiana	645	525	-	289	418	+
Iowa	350	0	-	153	0	-
Kansas	265	818	+	119	170	+
Kentucky	400	236	-	179	27	-
Louisiana	440	950	+	196	321	+
Maine	115	0	-	51	0	-
Maryland	475	366	-	212	156	-
Massachusetts	710	478	-	315	70	-
Michigan	1,100	1,322	+	494	249	-
Minnesota	475	198	-	212	84	-
Mississippi	265	42	-	119	22	-
Missouri	570	322	-	255	83	-
Montana	75	160	+	34	40	
Nebraska	190	80	-	85	30	-
Nevada	55	0	-	25	0	-
New Hampshire	95	0	-	42	0	-
New Jersey	890	20	-	400	5	-
New Mexico	135	114	-	60	28	-
New York	2,260	1,240		1,012	342	-
North Carolina	630	128	-	281	19	-
North Dakota	75	0	-	34	0	-

Political Unit	Enrollments			Graduates		
	Projected[a]	Actual[b]	Conformity[c]	Projected[a]	Actual[b]	Conformity[c]
Ohio	1,330	1,183	-	595	436	-
Oklahoma	310	162	-	136	37	-
Oregon	265	588	+	119	136	
Pennsylvania	1,460	543	-	655	162	-
Rhode Island	115	70	-	51	24	-
South Carolina	320	68	-	145	16	-
South Dakota	75	0	-	34	0	-
Tennessee	475	942	+	212	242	
Texas	1,390	1,270	-	220	190	-
Utah	135	897	+	60	202	+
Vermont	55	8	-	25	2	-
Virginia	570	252	-	255	63	-
Washington	420	189	-	187	44	-
West Virginia	210	165	-	93	42	-
Wisconsin	550	1,333	+	246	201	-
Wyoming	40	0	-	17	0	-

[a]Data from Table 79

[b]Data estimated in many cases; see Appendix G.

[c]Apparent surpluses (+) and deficits (-) of actual values when compared to model; no entry indicates reasonable conformity to model.

able for either engineering technology enrollments or engineering technology graduates; hence, many of the "actual" values listed in these tables are estimates based on past trends rather than being reported data. For this reason, then, the tables may badly misrepresent the relative effort in some states.

Since the available data related to enrollments in and graduates from engineering technology curricula are often incomplete, a method has been devised to estimate these statistics for use here. The method is based on two premises:

1. From one year to the next, enrollments at a particular institution do not change greatly; that is, a missing entry for enrollment in 1970 is probably very nearly the same as a reported enrollment for 1969.

2. The ratio of total enrollment to graduates is sensibly a constant with a numerical value of 3.64.

The first premise was established by examination of all data which were complete for consecutive years. While some variations were noted, i.e., enrollments did not remain exactly constant, these variations were almost insignificant when total enrollments by state were considered. The second premise was established by computing this ratio for all institutions which has complete data on enrollments and graduates for two consecutive years.

Data problems of the type illustrated in Table 82 are commonly encountered. A college may report enrollment but not graduates (College A in the illustration), graduates but not enrollment (College B in the example), or neither enrollments nor graduates (College C). In the first two cases, the 3.64 ratio can be appropriately applied to estimate the missing entry. In the third case, no estimate can be made unless *historical* data of some type are available. For example, if College C had reported an enrollment of 180 for the previous year (or any previous year), that figure would be assumed for the current year; then graduates would be computed as before.

The results of such estimations are shown in Table 83.

TABLE 82.--Illustrative Example of Data Problems

Institution	Total Enrollment	Number of Graduates
College A	425	--
College B	--	60
College C	--	--

TABLE 83.--Illustrative Examples of Estimates Used in Solving Data Problems

Institution	Total Enrollment	Number of Graduates
College A	425	*116*
College B	*218*	60
College C	*180*	*49*

No claims of reliability or validity are made for the technique, and no estimates are available for the probable error in the results. The estimates generated, however, are believed valuable in presenting a general overview of the national enterprise in engineering technology education.

Comments on Tables 80 and 81

An examination of Table 80 reveals that only 20 states have enrollments in associate degree (or lower division) engineering technology programs that equal or exceed the enrollment called for by the model; an even smaller number of states (15) produce a number of graduates which equals or exceeds the number projected. In the United States as a whole, enrollments would have to be increased by approximately 10 percent to achieve the level deemed desirable. It may also be important that at least five states are providing for less than one-fifth their "quotas" of enrollment; where this is true, a serious lack of educational opportunity exists. It is also interesting to observe that the more populous states--notably California, New York and Pennsylvania--conform closely with the model.

The data in Table 81 are even less encouraging. Only 12 states have enrollments in baccalaureate engineering technology programs (upper division) that equal or exceed the model projections, and only 8 produce graduates in the numbers projected. Relative to projected need, the educational opportunities existing for baccalaureate study are proportionately far fewer than for associate degree or lower division study. The national production of graduates is less than half that projected in the model.

Summary and Conclusions

A statistical model for engineering technology education suggests that, in order to meet projected national manpower needs for approximately 33,000 college-trained technicians per year, about 66,000 freshmen annually must enter engineering technology curricula. The model allows for half of those who enter to graduate. If 33,000 engineering technicians were graduated annually, the technical manpower gap which has existed for decades would be closed. The model also provides for 13,200 of the 33,000 annual recepients of associate degrees in engineering technology to seek baccalaureate degrees in that field, and predicts that 11,220 will attain the higher degree. The total number of "college-trained" technicians (with associate or higher degrees) matches in the model the number of job opportunities expected to be available.

The model carries with it implications for student enrollments in engineering technology education programs at various levels; it also implies an apportionment of these students on a state-by-state basis. Comparison of the projections of the detailed model with actual data shows roughly how each state is meeting the challenge of providing equally accessible educational opportunity in this curricular area.

The projections of the model are, in the case of most states, moderately or substantially greater than the actual enrollments or graduates in those states. The discrepancies are not uncorrectably large; progress can and should be made toward achieving a more realistic match between educational efforts and manpower needs.

APPENDICES

APPENDIX A

INSTITUTIONS TENTATIVELY IDENTIFIED AS OFFERING ENGINEERING TECHNOLOGY CURRICULA

Institutions Offering Curricula Which Lead to the Award of Associate Degrees

ALABAMA

Gadsden State Junior College
Jefferson State Junior College
John C. Calhoun State Junior College
Snead State Junior College
University of Alabama, Huntsville

ALASKA

Anchorage Community College

ARIZONA

Arizona Western College
Cochise College
DeVry Institute of Technology
Eastern Arizona College
Glendale Community College
Maricopa Technical College
Mesa College
Phoenix College

ARKANSAS

Southern State College
Southwest Technical Institute

CALIFORNIA

Allan Hancock College
American River College
Antelope Valley College
Barstow Junior College
Butte College
Cabrillo College
Cerritos College
Chabot College
Chaffey College

CALIFORNIA (Continued)

City College of San Francisco
Cogswell Polytechnical College
College of Marin
College of the Desert
College of the Siskiyous
Compton College
Contra Costa College
Cuesta College
Cosumnes River College
De Anza College
Diablo Valley College
East Los Angeles College
El Camino College
Foothill College
Fresno City College
Fullerton Junior College
Golden West College
Grantham School of Engineering
Hartnell College
Heald Engineering College
Humphreys College
Los Angeles City College
Los Angeles Harbor College
Los Angeles Pierce College
Los Angeles Valley College
Mesa Community College
Modesto Junior College
Monterey Peninsula College
Moorpark College
Mount San Antonio College
Napa College
Northrup Institute of Technology
Orange Coast College
Pasadena City College
Rio Hondo College
Sacramento City College
San Bernardino Valley College
San Diego Community College
San Joaquin Delta College
Santa Ana College
Santa Barbara College
Santa Monica City College

Santa Rosa College
Shasta College
Sierra College
Solano College
Southwestern College
Taft College
Ventura College
Victor Valley College
West Hills College
West Valley College
Western States College of Engineering
Yuba College

COLORADO

Arapahoe Junior College
Lamar Junior College
Mesa College
Metropolitan State College
Northeastern Junior College
Otero Junior College
South Colorado State College

CONNECTICUT

Hartford State Technical College
Norwalk State Technical College
Thames Valley State Technical College
Ward Technical Institute
Waterbury Technical Institute

DELAWARE

Delaware Technical & Community College

D.C.

Washington Technical Institute

FLORIDA

Brevard Junior College
Broward Junior College
Central Florida Junior College
Chipola Junior College
Daytona Beach Junior College
Edison Junior College
Embry-Riddle Aeronautical University
Florida Junior College
Florida Keys Junior College

FLORIDA (Continued)

Gulf Coast Junior College
Indian River Junior College
Lake City Junior College
Lake-Sumter Junior College
Manatee Junior College
Massey Technical Institute
Miami-Dade Junior College-North
North Clearwater Technical Education Center
Okaloosa-Walton Junior College
Palm Beach Junior College
Pensacola Junior College
Polk Junior College
St. John's River Junior College
St. Petersburg Junior College
Santa Fe Junior College
Tampa Technical Institute
Valencia Junior College

GEORGIA

DeKalb College
Southern Technical Institute

HAWAII

Maui Community College

IDAHO

Boise State College
Ricks College

ILLINOIS

Belleville Junior College
Black Hawk College
Bradley University
Chicago City College - Fenger
Chicago City College - Wright
Chicago Technical College
College of DuPage - Glen Ellyn
Coyne Electronics Institute
Crane Junior College
DeVry Institute of Technology
Highlands Community College
Illinois Valley Community College
Industrial Engineering College
Joliet Junior College

ILLINOIS (Continued)

Kaskaskia College
Parks College of St. Louis University
Prairie State College
Rock Valley College
Sauk Valley College
Spoon Valley College
Thornton Community College
Wm. Rainey Harper College

INDIANA

ITT Educational Services - Evansville
ITT Educational Services - Ft. Wayne
ITT Educational Services - Indianapolis
Purdue University
Tri-State College
Valparaiso Technical Institute
Vincennes University

IOWA

East Iowa Community College - Clinton
East Iowa Community College - Davenport
East Iowa Community College - Scott
Ellsworth Community College
Hawkeye Institute of Technology
Iowa Central Community College
Iowa State University Technical Institute
[Iowa] Area XV Community College
Iowa Western Community College
Kirkwood Community College
Marshalltown Community College
North Iowa Area Community College
Southeastern Community College
Waldorf College

KANSAS

Butler County Community Jr. College
Hutchinson Community Junior College
Kansas City Community Junior College
Kansas Technical Institute

KENTUCKY

Ashland Community College
Eastern Kentucky University

KENTUCKY (Continued)

Henderson Community College
Lexington Technical Institute
Somerset Community College
Southeast Community College
Western Kentucky University

LOUISIANA

Delgado College
Northwestern State College

MAINE

Southern Maine Vocational/Technical Institute
University of Maine

MARYLAND

Allegany Community College
Anne Arundel Community College
Capitol Institute of Technology
Catonsville Community College
Charles County Community College
Community College of Baltimore
Hagerstown Junior College
Harford Junior College
Montgomery College
Prince Georges Community College

MASSACHUSETTS

Blue Hills Regional Technical Institute
Berkshire Community College
Dean Junior College
Franklin Institute of Boston
Gennesee Community College
Holyoke Community College
Lowell Technological Institute
Massasoit Community College
Merrimack College
Mount Wachusett Community College
Newton Junior College
North Shore Community College
Northeast Institute of Industrial Technology
Northern Essex Community College.
Quinsigamond College
Springfield Technical Community College
Wentworth Institute
Southeast Massachusetts University

MICHIGAN

Delta College
Ferris State College
Flint Community Junior College
Grand Rapids Junior College
Henry Ford Community College
Jackson Community College
Kellogg Community College
Lake Michigan College
Lake Superior State College
Lansing Community College
Laurence Institute of Technology
Macomb County Community College
Michigan Technological University
Monroe County Community College
Muskegon Community College
Oakland Community College
Schoolcraft College
Southwest Michigan College
Washtenaw Community College

MINNESOTA

Anoka-Ramsey State Junior College
Austin State Junior College
Hibbing State Junior College
North Hennepin State Junior College
Rochester State Junior College
Southwest Minnesota State College

MISSISSIPPI

Jackson County Junior College
Jefferson Davis Junior College
Mississippi Delta Junior College
Mississippi Gulf Coast Junior College
Northeast Mississippi Junior College
Northwest Mississippi Junior College

MISSOURI

Central Technical Institute
Crowder College
Findlay Engineering College
Florissant Valley Community College
Forest Park Community College
Jefferson College

MISSOURI (Continued)

Kansas City Metro Junior College
Linn Technical College
Meramec Community College
Mineral Area College
Missouri Southern College
Penn Valley Community College

MONTANA

Miles Community College
Northern Montana College

NEBRASKA

Central Nebraska Technical College
Nebraska Vocational/Technical School
University of Nebraska - Curtis
University of Nebraska - Omaha
Western Nebraska Vocational/Technical School

NEVADA

Elko Community College
Nevada Technical Institute

NEW HAMPSHIRE

New Hampshire Technical Institute
New Hampshire Vocational/Technical College

NEW JERSEY

Cumberland County College
Mercer County Community College
Middlesex County College
Ocean County College
Union County Technical Institute

NEW MEXICO

Eastern New Mexico University
New Mexico Highlands University
New Mexico Junior College
New Mexico State University - Las Cruces
North American Technical Institute
Western New Mexico University

NEW YORK

Academy of Aeronautics
Adirondack Community College
Auburn Community College

NEW YORK (Continued)

Bronx Community College
Broome Technical Community College
Duchess Community College
Erie Community College
Fashion Institute of Technology
Fulton-Montgomery Community College
Hudson Valley Community College
Jamestown Community College
Mohawk Valley Community College
Monroe Community College
Nassau Community College
New York City Community College
New York Institute of Technology
Niagra County Community College
Orange County Community College
Paul Smith's College
Queensborough Community College
Rochester Institute of Technology
RCA Institutes
Staten Island Community College
Suffolk County Community College
SUNY/Buffalo
SUNY/ATC/Alfred
SUNY/ATC/Canton
SUNY/ATC/Cobbleskill
SUNY/ATC/Delhi
SUNY/ATC/Farmingdale
SUNY/ATC/Morrisville
Ulster County Community College
Vorhees Technical Institute
Westchester Community College

NORTH CAROLINA

Asheville-Buncombe Technical Institute
Brevard College
Cape Fear Technical Institute
Catawpa Valley Technical Institute
Central Carolina Technical Institute
Central Piedmont Community College
College of the Albermarle
Davidson County Community College
Durham Technical Institute
Fayetteville Technical Institute

NORTH CAROLINA (Continued)

Forsythe Technical Institute
Gaston College
Guilford Technical Institute
Isothermal Community College
Lenoir Community College
Pitt Technical Institute
Richmond Technical Institute
Rowan Technical Institute
Southeastern Community College
Surrey Community College
Technical Institute of Alamance
Wayne Community College
Wilkes Community College
Wilson County Technical Institute
W. W. Holding Technical Institute

NORTH DAKOTA

North Dakota State School of Science

OHIO

American Technical Institute
Cincinnati Technical Institute
Clark County Technical Institute
Columbus Technical Institute
Cuyahoga Community College
Electrical Engineering Technical Institute
Franklin University
Griswold Institute
ITT Technical Institute
Kent State University
Lakeland Community College
Lorain County Community College
Miami University - Middletown
Miami University - Oxford
North Central Ohio Technical Institute
Ohio College of Applied Science
Ohio Technical College
Sinclair Community College
Tri-County Technical Institute
University of Akron Community College
University of Dayton Technical Institute
University of Toledo, Community & Technical College

OKLAHOMA

Connors State College
East Oklahoma State College
Murray State College
Northeast Oklahoma A&M College
North Oklahoma College
Oklahoma State University - Oklahoma City
Oklahoma State University - Stillwater
Sayre Junior College

OREGON

Blue Mountain Community College
Central Oregon Community College
Lane Community College
Mount Hood Community College
Oregon Technical Institute
Portland Community College
Salem Vocational/Technical Community College
Southwest Oregon Community College
Umpqua Community College

PENNSYLVANIA

Bucks County Community College
Community College of Allegheny County
Community College of Beaver County
Community College of Delaware County
Community College of Philadelphia
Harrisburg Area Community College
Lehigh County Community College
Luzerne County Community College
Northampton County Community College
Pennsylvania State University
Point Park College
Spring Garden College
Temple University Technical Institute
Williamsport Area Community College
York College of Pennsylvania

RHODE ISLAND

Rhode Island Junior College
Roger Williams College

SOUTH CAROLINA

Florence Technical Education Center
Greenville Technical Education Center

SOUTH CAROLINA (Continued)

Midlands Technical Education Center
Palmer College
Piedmont Technical Education Center
Spartanburg Technical Education Center
Tri-County Technical Education Center
York County Technical Education Center

SOUTH DAKOTA

Lake Area Vocational/Technical School
Southern State College

TENNESSEE

Chattanooga State Technical Institute
Nashville State Technical Institute
State Technical Institute - Memphis

TEXAS

Amarillo College
Del Mar College
El Centro College
Grayson County Junior College
Henderson County College
Hill Junior College
Kilgore College
Le Tourneau College
Lee College
San Antonio College
San Jacinto College
South Plains College
Tarrant County Junior College District
Texarkana College
Texas State Technical Institute
University of Texas/Arlington
Wharton County Junior College

UTAH

Brigham Young University
Utah Technological College - Provo
Utah Technological College - Salt Lake
Weber State College

VERMONT

Vermont Technical College

VIRGINIA

Blue Ridge Community College
Danville Community College
D. S. Lancaster Community College
Ferrum Junior College
John Tyler Community College
North Virginia Community College
Old Dominion University
Radford-Dublin Community College
Tidewater Community College
Virginia Western Community College
Wytheville Community College

WASHINGTON

Centralia College
Clark College
Columbia Basin Community College
Fort Steilacoom Community College
Grays Harbor College
Green River Community College
Highline Community College
Lower Columbia College
Olympic Community College
Peninsula Community College
Seattle Community College
Shoreline Community College
Skagit Valley College
Spokane Community College
Wenatchee Valley College.
Yakima Valley College

WEST VIRGINIA

Bluefield State College
Fairmont State College
Potomac State College
West Liberty State College
West Virginia Institute of Technology

WISCONSIN

District Eleven Vocational/Technical School
District One Technical Institute
Fond du Lac Technical Institute
Fox Valley Technical Institute
Kenosha Technical Institute

Madison Area Technical College
Mid-State Technical Institute
Milwaukee Area Technical College
Milwaukee School of Engineering
North Central Technical Institute
Northeast Wisconsin Technical Institute
Racine Technical Institute
Rice-Lake Vocational/Technical School
Superior Technical Institute
Waukesha County Technical Institute
Western Wisconsin Technical Institute

WYOMING

Casper College
Central Wyoming College
Northwest Community College
Sheridan College

OTHER

University of Puerto Rico

Institutions Offering Curricula Which Lead to the Award of Baccalaureate Degrees

ALABAMA

Alabama A&M University
Tuskegee Institute

ALASKA

ARIZONA

Arizona State University
DeVry Institute of Technology - Phoenix
Northern Arizona University

ARKANSAS

John Brown University

CALIFORNIA

California State College - Long Beach
California State Polytechnical College - San Luis Obispo
Northrup Institute of Technology
San Jose State College

COLORADO

Metropolitan State College
South Colorado State College

CONNECTICUT

DELAWARE

D.C.

FLORIDA

Embry-Riddle Aeronautical University
Florida A&M University
University of South Florida

GEORGIA

Georgia Southern College
Southern Technical Institute

HAWAII

Church College of Hawaii

IDAHO

ILLINOIS

Bradley University
DeVry Institute of Technology - Chicago
Eastern Illinois University
Industrial Engineering College
Parks College - St. Louis University
Southern Illinois University
University of Illinois

INDIANA

Indiana University/Purdue University - Indianapolis
Purdue University
Valparaiso Technical Institute

IOWA

KANSAS

Kansas State College - Pittsburg
Kansas State Teachers College

KENTUCKY

Eastern Kentucky University
Western Kentucky University

LOUISIANA

Louisiana Polytechnic Institute
Louisiana State University
Northwestern State College
Southeastern Louisiana College
Southern University
University of Southwest Louisiana

MARYLAND

Capitol Institute of Technology
University of Maryland

MASSACHUSETTS

Boston University
Lowell Technological Institute
Northeastern University - Lincoln College
Southeast Massachusetts University
Wentworth College

MICHIGAN

Northern Michigan University
Western Michigan University

MINNESOTA

Mankato State College
Moorhead State College
Southwest Minnesota State College
University of Minnesota

MISSISSIPPI

Mississippi State University

MISSOURI

Central Missouri State College
Findlay Engineering College
Southeast Missouri State College

MONTANA

Montana State University

NEBRASKA

Kearny State College
University of Nebraska - Omaha

NEVADA

NEW HAMPSHIRE

NEW JERSEY

Montclair College

NEW MEXICO

New Mexico State University - Las Cruces

NEW YORK

New York Institute of Technology
Rochester Institute of Technology
Syracuse University College

NORTH CAROLINA

North Carolina State University
North Carolina A&T University
University of North Carolina - Charlotte

NORTH DAKOTA

OHIO

Bowling Green State University
Cleveland State University
Franklin University
Kent State University
Miami University
Ohio Techical College
Ohio University
University of Akron
University of Dayton

OKLAHOMA

Oklahoma State University

OREGON

Oregon State University
Oregon Technical Institute

PENNSYLVANIA

Pennsylvania State University
Point Park College
Spring Garden College
Temple University

RHODE ISLAND

Roger Williams College

SOUTH CAROLINA

South Carolina State College

SOUTH DAKOTA

TENNESSEE

Austin Peay State University
East Tennessee State University
Memphis State University
Middle Tennessee State University
Tennessee Technological University

TEXAS

East Texas State University
Le Tourneau College
Texas A&M University
Texas Technological University
University of Houston

UTAH

Brigham Young University
Utah State University
Weber State College
Southern Utah State College

VERMONT

University of Vermont

VIRGINIA

Hampton Institute
Old Dominion University

WASHINGTON

Central Washington State College
Walla Walla College
Western Washington State College

WEST VIRGINIA

Bluefield State College
Fairmont State College

WISCONSIN

Acme Institute of Technology
Milwaukee School of Engineering
Stout State University
Wisconsin State University - Platteville

WYOMING

OTHER

APPENDIX B

ENGINEERING TECHNOLOGY EDUCATION STUDY

Curriculum Survey
MATHEMATICS

Please indicate, by checking the appropriate space, the extent to which each of the following concepts or topics is treated in your syllabus for the Mathematics courses offered for students in engineering technology curricula. If your course outlines normally include additional topics please add them at the end of the list

Please observe the following codes in checking spaces for your response

1 = Not Covered
2 = Introduced Only
3 = Brief Discussion
4 = Covered in some Depth
5 = Covered in Detail

	1	2	3	4	5
The Number System of Algebra					
Sets	[ ]	[ ]	[ ]	[ ]	[ ]
The natural numbers	[ ]	[ ]	[ ]	[ ]	[ ]
The real-number system	[ ]	[ ]	[ ]	[ ]	[ ]
The Fundamental Operations					
The relation of equality	[ ]	[ ]	[ ]	[ ]	[ ]
Addition of monomials and polynomials	[ ]	[ ]	[ ]	[ ]	[ ]
Subtraction of monomials and polynomials	[ ]	[ ]	[ ]	[ ]	[ ]
Axioms and theorems of multiplication	[ ]	[ ]	[ ]	[ ]	[ ]
Law of signs for multiplication	[ ]	[ ]	[ ]	[ ]	[ ]
Law of exponents in multiplication	[ ]	[ ]	[ ]	[ ]	[ ]
Multiplication of two or more expressions	[ ]	[ ]	[ ]	[ ]	[ ]
Division of algebraic expressions	[ ]	[ ]	[ ]	[ ]	[ ]
Special Products and Factoring					
The product of two binomials	[ ]	[ ]	[ ]	[ ]	[ ]
The product of two trinomials	[ ]	[ ]	[ ]	[ ]	[ ]
The square of a polynomial	[ ]	[ ]	[ ]	[ ]	[ ]
Factoring	[ ]	[ ]	[ ]	[ ]	[ ]
Factors of a quadratic trinomial	[ ]	[ ]	[ ]	[ ]	[ ]
Trinomials that are perfect squares	[ ]	[ ]	[ ]	[ ]	[ ]
Factors of a binomial	[ ]	[ ]	[ ]	[ ]	[ ]
Common factors	[ ]	[ ]	[ ]	[ ]	[ ]
Factoring by grouping	[ ]	[ ]	[ ]	[ ]	[ ]
Difference of two squares	[ ]	[ ]	[ ]	[ ]	[ ]
Fractions					
Conversion of fractions	[ ]	[ ]	[ ]	[ ]	[ ]
Multiplication of fractions	[ ]	[ ]	[ ]	[ ]	[ ]
Division of fractions	[ ]	[ ]	[ ]	[ ]	[ ]
The lowest common denominator	[ ]	[ ]	[ ]	[ ]	[ ]
Addition of fractions	[ ]	[ ]	[ ]	[ ]	[ ]
Complex fractions	[ ]	[ ]	[ ]	[ ]	[ ]
Exponents and Radicals					
Nonnegative integral exponents	[ ]	[ ]	[ ]	[ ]	[ ]
Negative integral exponents	[ ]	[ ]	[ ]	[ ]	[ ]
Roots of numbers	[ ]	[ ]	[ ]	[ ]	[ ]
Rational exponents	[ ]	[ ]	[ ]	[ ]	[ ]
Conversion of exponential expressions	[ ]	[ ]	[ ]	[ ]	[ ]
The product and quotient of two radicals	[ ]	[ ]	[ ]	[ ]	[ ]
Rationalizing monomial denominators	[ ]	[ ]	[ ]	[ ]	[ ]
Changing the order of a radical	[ ]	[ ]	[ ]	[ ]	[ ]
Addition of radicals	[ ]	[ ]	[ ]	[ ]	[ ]
Additional operations involving radicals	[ ]	[ ]	[ ]	[ ]	[ ]
Linear and Fractional Equations					
Equivalent equations	[ ]	[ ]	[ ]	[ ]	[ ]
Linear equations in one unknown	[ ]	[ ]	[ ]	[ ]	[ ]
Fractional equations	[ ]	[ ]	[ ]	[ ]	[ ]
Solving stated problems	[ ]	[ ]	[ ]	[ ]	[ ]

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Quadratic Equations					
Solution by factoring	[ ]	[ ]	[ ]	[ ]	[ ]
Solution by completing the square	[ ]	[ ]	[ ]	[ ]	[ ]
Complex numbers	[ ]	[ ]	[ ]	[ ]	[ ]
The quadratic formula	[ ]	[ ]	[ ]	[ ]	[ ]
Equations in quadratic form	[ ]	[ ]	[ ]	[ ]	[ ]
Equations that involve radicals of the second order	[ ]	[ ]	[ ]	[ ]	[ ]
Problems that lead to quadratic equations	[ ]	[ ]	[ ]	[ ]	[ ]
Nature of the roots	[ ]	[ ]	[ ]	[ ]	[ ]
The sum and product of the roots	[ ]	[ ]	[ ]	[ ]	[ ]
Factors of a quadratic trinomial	[ ]	[ ]	[ ]	[ ]	[ ]
Functions and Graphs					
Ordered pairs of numbers	[ ]	[ ]	[ ]	[ ]	[ ]
Functions	[ ]	[ ]	[ ]	[ ]	[ ]
Functional notation	[ ]	[ ]	[ ]	[ ]	[ ]
Relations	[ ]	[ ]	[ ]	[ ]	[ ]
The rectangular coordinate system	[ ]	[ ]	[ ]	[ ]	[ ]
The graph of a function	[ ]	[ ]	[ ]	[ ]	[ ]
The inverse of a function	[ ]	[ ]	[ ]	[ ]	[ ]
Systems of Equations					
Equations in two variables	[ ]	[ ]	[ ]	[ ]	[ ]
Graphs of equations in two variables	[ ]	[ ]	[ ]	[ ]	[ ]
Graph of a quadratic equation in two variables	[ ]	[ ]	[ ]	[ ]	[ ]
Graph of a linear equation in two variables	[ ]	[ ]	[ ]	[ ]	[ ]
Graphical solution of a system of equations	[ ]	[ ]	[ ]	[ ]	[ ]
Consistent, inconsistent, and dependent equations	[ ]	[ ]	[ ]	[ ]	[ ]
Algebraic methods of solution, system of equations	[ ]	[ ]	[ ]	[ ]	[ ]
Elimination by addition or subtraction	[ ]	[ ]	[ ]	[ ]	[ ]
Elimination by substitution	[ ]	[ ]	[ ]	[ ]	[ ]
Elimination by a combination of addition or subtraction and substitution	[ ]	[ ]	[ ]	[ ]	[ ]
Symmetric equations	[ ]	[ ]	[ ]	[ ]	[ ]
Problems leading to systems of equations	[ ]	[ ]	[ ]	[ ]	[ ]
Problems solvable by means of simultaneous quadratics	[ ]	[ ]	[ ]	[ ]	[ ]
Elementary Determinants with Applications					
Determinants of the second order	[ ]	[ ]	[ ]	[ ]	[ ]
Solution of a system of two linear equations	[ ]	[ ]	[ ]	[ ]	[ ]
Systems of three linear equations	[ ]	[ ]	[ ]	[ ]	[ ]
Determinants of the third order	[ ]	[ ]	[ ]	[ ]	[ ]
Solution of a system of three linear equations	[ ]	[ ]	[ ]	[ ]	[ ]
Complex Numbers					
Definitions	[ ]	[ ]	[ ]	[ ]	[ ]
Fundamental operations on complex numbers	[ ]	[ ]	[ ]	[ ]	[ ]
Geometrical representation	[ ]	[ ]	[ ]	[ ]	[ ]
Geometric addition and subtraction	[ ]	[ ]	[ ]	[ ]	[ ]
Polar representation	[ ]	[ ]	[ ]	[ ]	[ ]
The product of two complex numbers in polar form	[ ]	[ ]	[ ]	[ ]	[ ]
The quotient of two complex numbers in polar form	[ ]	[ ]	[ ]	[ ]	[ ]
De Moivre's theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Roots of complex numbers	[ ]	[ ]	[ ]	[ ]	[ ]

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Higher-Degree Equations					
Rational-integral equations	[ ]	[ ]	[ ]	[ ]	[ ]
The remainder theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Factor theorem and its converse	[ ]	[ ]	[ ]	[ ]	[ ]
Synthetic division	[ ]	[ ]	[ ]	[ ]	[ ]
Graph of a polynomial	[ ]	[ ]	[ ]	[ ]	[ ]
Locating the roots	[ ]	[ ]	[ ]	[ ]	[ ]
Number of Roots	[ ]	[ ]	[ ]	[ ]	[ ]
Bounds of the real roots	[ ]	[ ]	[ ]	[ ]	[ ]
Rational roots of a polynomial equation	[ ]	[ ]	[ ]	[ ]	[ ]
The depressed equation	[ ]	[ ]	[ ]	[ ]	[ ]
Process of obtaining all rational roots	[ ]	[ ]	[ ]	[ ]	[ ]
Descartes's rule of signs	[ ]	[ ]	[ ]	[ ]	[ ]
Imaginary roots	[ ]	[ ]	[ ]	[ ]	[ ]
Irrational roots by successive magnification	[ ]	[ ]	[ ]	[ ]	[ ]
Transformation of an equation to decrease its roots	[ ]	[ ]	[ ]	[ ]	[ ]
Horner's method for determining irrational roots	[ ]	[ ]	[ ]	[ ]	[ ]
Identical polynomials	[ ]	[ ]	[ ]	[ ]	[ ]
The cubic equation	[ ]	[ ]	[ ]	[ ]	[ ]
The quartic equation	[ ]	[ ]	[ ]	[ ]	[ ]
Inequalities					
Definitions, fundamental axioms, and theorems	[ ]	[ ]	[ ]	[ ]	[ ]
Conditional inequalities	[ ]	[ ]	[ ]	[ ]	[ ]
Ratio, Proportion, and Variation					
Ratio	[ ]	[ ]	[ ]	[ ]	[ ]
Proportion	[ ]	[ ]	[ ]	[ ]	[ ]
Variation	[ ]	[ ]	[ ]	[ ]	[ ]
Logarithms					
Definitions	[ ]	[ ]	[ ]	[ ]	[ ]
Properties of logarithms	[ ]	[ ]	[ ]	[ ]	[ ]
Approximations	[ ]	[ ]	[ ]	[ ]	[ ]
Scientific notation	[ ]	[ ]	[ ]	[ ]	[ ]
Common, or Briggs, Logarithms	[ ]	[ ]	[ ]	[ ]	[ ]
Characteristic and mantissa	[ ]	[ ]	[ ]	[ ]	[ ]
Use of tables to obtain the mantissa	[ ]	[ ]	[ ]	[ ]	[ ]
Use of tables to find N when log N is given	[ ]	[ ]	[ ]	[ ]	[ ]
Logarithmic computation	[ ]	[ ]	[ ]	[ ]	[ ]
Logarithms to bases other that 10	[ ]	[ ]	[ ]	[ ]	[ ]
Exponential and logarithmic equations	[ ]	[ ]	[ ]	[ ]	[ ]
The graphs of $\log_a x$ and of a^x	[ ]	[ ]	[ ]	[ ]	[ ]
Progressions					
Definition of progressions	[ ]	[ ]	[ ]	[ ]	[ ]
Arithmetic progressions	[ ]	[ ]	[ ]	[ ]	[ ]
Last term of an arithmetic progression	[ ]	[ ]	[ ]	[ ]	[ ]
Sum of an arithmetic progression	[ ]	[ ]	[ ]	[ ]	[ ]
Simultaneous use of the formulas for l and s	[ ]	[ ]	[ ]	[ ]	[ ]
Arithmetic means	[ ]	[ ]	[ ]	[ ]	[ ]
Geometric progressions	[ ]	[ ]	[ ]	[ ]	[ ]
Last term of a geometric progression	[ ]	[ ]	[ ]	[ ]	[ ]
Sum of a geometric progression	[ ]	[ ]	[ ]	[ ]	[ ]
Simultaneous use of the formulas for l and s	[ ]	[ ]	[ ]	[ ]	[ ]
Geometric means	[ ]	[ ]	[ ]	[ ]	[ ]
Infinite geometric progressions	[ ]	[ ]	[ ]	[ ]	[ ]
Harmonic progressions	[ ]	[ ]	[ ]	[ ]	[ ]

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Method of mathematical induction	[ ]	[ ]	[ ]	[ ]	[ ]
The Binomial Theorem					
The binomial formula	[ ]	[ ]	[ ]	[ ]	[ ]
The rth term of the binomial formula	[ ]	[ ]	[ ]	[ ]	[ ]
Proof of the binomial formula	[ ]	[ ]	[ ]	[ ]	[ ]
Binomial theorem for fractional and negative exponents.	[ ]	[ ]	[ ]	[ ]	[ ]
Permutations and Combinations					
Definitions	[ ]	[ ]	[ ]	[ ]	[ ]
The fundamental principle	[ ]	[ ]	[ ]	[ ]	[ ]
Permutations of n different elements taken r at a time	[ ]	[ ]	[ ]	[ ]	[ ]
Permutations of n elements not all different	[ ]	[ ]	[ ]	[ ]	[ ]
Cyclic permutations	[ ]	[ ]	[ ]	[ ]	[ ]
Combinations	[ ]	[ ]	[ ]	[ ]	[ ]
The sum of certain combinations	[ ]	[ ]	[ ]	[ ]	[ ]
Probability					
Mathematical probability	[ ]	[ ]	[ ]	[ ]	[ ]
Empirical probability	[ ]	[ ]	[ ]	[ ]	[ ]
Mathematical expectation	[ ]	[ ]	[ ]	[ ]	[ ]
Mutually exclusive events	[ ]	[ ]	[ ]	[ ]	[ ]
Independent events	[ ]	[ ]	[ ]	[ ]	[ ]
Dependent events	[ ]	[ ]	[ ]	[ ]	[ ]
Repeated trials of an event	[ ]	[ ]	[ ]	[ ]	[ ]
Determinants of Order N					
Inversions	[ ]	[ ]	[ ]	[ ]	[ ]
Determinants of order n	[ ]	[ ]	[ ]	[ ]	[ ]
Minors of a determinant	[ ]	[ ]	[ ]	[ ]	[ ]
Properties of determinants	[ ]	[ ]	[ ]	[ ]	[ ]
Simplification of a determinant	[ ]	[ ]	[ ]	[ ]	[ ]
Systems of linear equations	[ ]	[ ]	[ ]	[ ]	[ ]
Matrices	[ ]	[ ]	[ ]	[ ]	[ ]
Partial Fractions					
Definitions and theorems	[ ]	[ ]	[ ]	[ ]	[ ]
Distinct linear factors	[ ]	[ ]	[ ]	[ ]	[ ]
Repeated linear factors	[ ]	[ ]	[ ]	[ ]	[ ]
Distinct quadratic factors	[ ]	[ ]	[ ]	[ ]	[ ]
Repeated quadratic factors	[ ]	[ ]	[ ]	[ ]	[ ]
The Trigonometric Functions					
Directed segments	[ ]	[ ]	[ ]	[ ]	[ ]
The distance formula	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric angles	[ ]	[ ]	[ ]	[ ]	[ ]
Standard position of an angle	[ ]	[ ]	[ ]	[ ]	[ ]
Definitions of the trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Given one function, find the other functions	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric Functions of An Acute Angle					
Trigonometric functions of an acute angle	[ ]	[ ]	[ ]	[ ]	[ ]
Cofunctions	[ ]	[ ]	[ ]	[ ]	[ ]
Variation of the functions of an acute angle	[ ]	[ ]	[ ]	[ ]	[ ]
The trigonometric functions of 30°, 45°, 60°	[ ]	[ ]	[ ]	[ ]	[ ]
Tables of trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Interpolation	[ ]	[ ]	[ ]	[ ]	[ ]
Approximations and significant figures	[ ]	[ ]	[ ]	[ ]	[ ]
The solution of right triangles	[ ]	[ ]	[ ]	[ ]	[ ]
Angles of elevation and depression	[ ]	[ ]	[ ]	[ ]	[ ]

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Trigonometric Identities					
The fundamental relations	[ ]	[ ]	[ ]	[ ]	[ ]
Algebraic operations	[ ]	[ ]	[ ]	[ ]	[ ]
Identities and conditional equations	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric identities	[ ]	[ ]	[ ]	[ ]	[ ]
Related Angles					
Related angles	[ ]	[ ]	[ ]	[ ]	[ ]
Reduction to functions of an acute angle	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric functions of negative angles	[ ]	[ ]	[ ]	[ ]	[ ]
Radian Measure					
The Radian	[ ]	[ ]	[ ]	[ ]	[ ]
Radians and degrees	[ ]	[ ]	[ ]	[ ]	[ ]
Length of a circular arc	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric functions of numbers	[ ]	[ ]	[ ]	[ ]	[ ]
Linear and angular velocity	[ ]	[ ]	[ ]	[ ]	[ ]
Graphs of the Trigonometric Functions					
Periodic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Variations of the sine and cosine	[ ]	[ ]	[ ]	[ ]	[ ]
Variation of the tangent	[ ]	[ ]	[ ]	[ ]	[ ]
Graphs of the trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Functions of Two Angles					
Functions of the sum of two angles	[ ]	[ ]	[ ]	[ ]	[ ]
Sin (A + B) and Cos (A + B)	[ ]	[ ]	[ ]	[ ]	[ ]
Tan (A + B)	[ ]	[ ]	[ ]	[ ]	[ ]
Sin (A - B), Cos (A - B), and Tan (A - B)	[ ]	[ ]	[ ]	[ ]	[ ]
Reduction of a Sin θ + b Cos θ to K Sin (θ+H)	[ ]	[ ]	[ ]	[ ]	[ ]
Double-angle formulas	[ ]	[ ]	[ ]	[ ]	[ ]
Half-angle formulas	[ ]	[ ]	[ ]	[ ]	[ ]
Product to sum formulas, sum to product formulas	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric Equations					
Trigonometric equations	[ ]	[ ]	[ ]	[ ]	[ ]
Solving a trigonometric equation	[ ]	[ ]	[ ]	[ ]	[ ]
Graphical Methods	[ ]	[ ]	[ ]	[ ]	[ ]
The Graph of y = a Sin bx	[ ]	[ ]	[ ]	[ ]	[ ]
The Graph of y = a Sin (bx + c)					
The Graph of y = Sin^n x					
Sketching curves by composition	[ ]	[ ]	[ ]	[ ]	[ ]
The Grpah of y = a Sin x + b Cos x	[ ]	[ ]	[ ]	[ ]	[ ]
Solution of Triangles	[ ]	[ ]	[ ]	[ ]	[ ]
Solution of right triangles	[ ]	[ ]	[ ]	[ ]	[ ]
Vectors	[ ]	[ ]	[ ]	[ ]	[ ]
The law of siner	[ ]	[ ]	[ ]	[ ]	[ ]
Application: SAA	[ ]	[ ]	[ ]	[ ]	[ ]
The ambiguous case: SSA	[ ]	[ ]	[ ]	[ ]	[ ]
The Law of Cosines					
Applications: SAS and SSS	[ ]	[ ]	[ ]	[ ]	[ ]
The Area of a triangle	[ ]	[ ]	[ ]	[ ]	[ ]
Inverse Trigonometric Functions	[ ]	[ ]	[ ]	[ ]	[ ]
Inverse trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Principal values of the inverse trigonometric functions					
Operations involving inverse trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Inverse functions	[ ]	[ ]	[ ]	[ ]	[ ]

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Special Topics					
The circular functions	[ ]	[ ]	[ ]	[ ]	[ ]
Circular and exponential functions	[ ]	[ ]	[ ]	[ ]	[ ]
Solving oblique triangles SAS and SSS	[ ]	[ ]	[ ]	[ ]	[ ]
The law of tangents	[ ]	[ ]	[ ]	[ ]	[ ]
Applications of the law of tangents: SAS	[ ]	[ ]	[ ]	[ ]	[ ]
The half-angle formulas	[ ]	[ ]	[ ]	[ ]	[ ]
Applications of the hald-angle formulas: SSS	[ ]	[ ]	[ ]	[ ]	[ ]
The mil as a unit of angular measure	[ ]	[ ]	[ ]	[ ]	[ ]
Coordinates and Lines					
Number system	[ ]	[ ]	[ ]	[ ]	[ ]
Rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Distance between two points	[ ]	[ ]	[ ]	[ ]	[ ]
Point on the line joining two points	[ ]	[ ]	[ ]	[ ]	[ ]
Area of a triangle	[ ]	[ ]	[ ]	[ ]	[ ]
Inclination and slope	[ ]	[ ]	[ ]	[ ]	[ ]
Parallel and perpendicular lines	[ ]	[ ]	[ ]	[ ]	[ ]
Angle between two lines	[ ]	[ ]	[ ]	[ ]	[ ]
The locus of a point	[ ]	[ ]	[ ]	[ ]	[ ]
Equation of a straight line	[ ]	[ ]	[ ]	[ ]	[ ]
Standard equation of lines	[ ]	[ ]	[ ]	[ ]	[ ]
Intersection of lines	[ ]	[ ]	[ ]	[ ]	[ ]
Distance from a line to a point	[ ]	[ ]	[ ]	[ ]	[ ]
Family of lines	[ ]	[ ]	[ ]	[ ]	[ ]
Line through the intersection of two lines	[ ]	[ ]	[ ]	[ ]	[ ]
Variables, Functions, and Limits					
Rate of change	[ ]	[ ]	[ ]	[ ]	[ ]
The conce... ...a	[ ]	[ ]	[ ]	[ ]	[ ]
Constants ... ...ables	[ ]	[ ]	[ ]	[ ]	[ ]
Functions	[ ]	[ ]	[ ]	[ ]	[ ]
Limit of a function	[ ]	[ ]	[ ]	[ ]	[ ]
Continuity	[ ]	[ ]	[ ]	[ ]	[ ]
Infinity	[ ]	[ ]	[ ]	[ ]	[ ]
Limit of a sequence	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation and Applications					
Increments	[ ]	[ ]	[ ]	[ ]	[ ]
Derivative	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of powers of x	[ ]	[ ]	[ ]	[ ]	[ ]
Slop of a curve	[ ]	[ ]	[ ]	[ ]	[ ]
Velocity and acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Maxima and minima	[ ]	[ ]	[ ]	[ ]	[ ]
Critical points	[ ]	[ ]	[ ]	[ ]	[ ]
Higher derivatives	[ ]	[ ]	[ ]	[ ]	[ ]
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Differentials	[ ]	[ ]	[ ]	[ ]	[ ]
Approximations and errors	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of Algebraic Forms					
Antidifferentiation	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of powers	[ ]	[ ]	[ ]	[ ]	[ ]
Constant of integration	[ ]	[ ]	[ ]	[ ]	[ ]
Differential of area	[ ]	[ ]	[ ]	[ ]	[ ]
Area as an integral	[ ]	[ ]	[ ]	[ ]	[ ]
Calculation of areas	[ ]	[ ]	[ ]	[ ]	[ ]
Area as a limit	[ ]	[ ]	[ ]	[ ]	[ ]
Definite integral	[ ]	[ ]	[ ]	[ ]	[ ]
Fundamental theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Plane areas in rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Volumes of solids of revolution	[ ]	[ ]	[ ]	[ ]	[ ]

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Applications of Integration	[ ]	[ ]	[ ]	[ ]	[ ]
Moment of mass, centroids	[ ]	[ ]	[ ]	[ ]	[ ]
Centroid of a plane area	[ ]	[ ]	[ ]	[ ]	[ ]
Centroid of a solid of revolution	[ ]	[ ]	[ ]	[ ]	[ ]
Moment of inertia	[ ]	[ ]	[ ]	[ ]	[ ]
Radius of gyration	[ ]	[ ]	[ ]	[ ]	[ ]
Moment of inertia of an area	[ ]	[ ]	[ ]	[ ]	[ ]
Moment of inertia of a solid of revolution	[ ]	[ ]	[ ]	[ ]	[ ]
Fluid pressure	[ ]	[ ]	[ ]	[ ]	[ ]
Work	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation of Algebraic Functions					
Formulas for differentiation	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation of implicit functions	[ ]	[ ]	[ ]	[ ]	[ ]
Equations of the Second Degree	[ ]	[ ]	[ ]	[ ]	[ ]
The graph of an equation	[ ]	[ ]	[ ]	[ ]	[ ]
Equations of the second degree	[ ]	[ ]	[ ]	[ ]	[ ]
The circle	[ ]	[ ]	[ ]	[ ]	[ ]
Circle determined by three conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Radical axis	[ ]	[ ]	[ ]	[ ]	[ ]
The parabola	[ ]	[ ]	[ ]	[ ]	[ ]
Another construction of a parabola	[ ]	[ ]	[ ]	[ ]	[ ]
General equations of a parabola	[ ]	[ ]	[ ]	[ ]	[ ]
Parabolas determined by three conditions	[ ]	[ ]	[ ]	[ ]	[ ]
The ellipse	[ ]	[ ]	[ ]	[ ]	[ ]
Another construction of an ellipse	[ ]	[ ]	[ ]	[ ]	[ ]
General equations of an ellipse	[ ]	[ ]	[ ]	[ ]	[ ]
Ellipses determined by four conditions	[ ]	[ ]	[ ]	[ ]	[ ]
The hyperbola	[ ]	[ ]	[ ]	[ ]	[ ]
Asymptotes	[ ]	[ ]	[ ]	[ ]	[ ]
General equations of a hyperbola	[ ]	[ ]	[ ]	[ ]	[ ]
Hyperbolas determined by four conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Translation of axes	[ ]	[ ]	[ ]	[ ]	[ ]
Rotation of axes	[ ]	[ ]	[ ]	[ ]	[ ]
Line tangent to a conic	[ ]	[ ]	[ ]	[ ]	[ ]
Poles and polars	[ ]	[ ]	[ ]	[ ]	[ ]
Tangents to a conic	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation of Transcendental Functions					
Transcendental functions	[ ]	[ ]	[ ]	[ ]	[ ]
Properties of trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Limit of $(\sin\theta)/\theta$	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Properties of inverse trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of inverse trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Exponential and logarithmic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of logarithmic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of exponential functions	[ ]	[ ]	[ ]	[ ]	[ ]
Summary and applications	[ ]	[ ]	[ ]	[ ]	[ ]
Parametric Equations, Curvature, and Roots					
Parametric representation	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives in parametric form	[ ]	[ ]	[ ]	[ ]	[ ]
Differential of Arc length	[ ]	[ ]	[ ]	[ ]	[ ]
Curvature	[ ]	[ ]	[ ]	[ ]	[ ]
Circle of curvature	[ ]	[ ]	[ ]	[ ]	[ ]
Center of curvature	[ ]	[ ]	[ ]	[ ]	[ ]
Evolutes	[ ]	[ ]	[ ]	[ ]	[ ]
Newton's method	[ ]	[ ]	[ ]	[ ]	[ ]

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Differentiation with Respect to Time					
Time-rates	[ ]	[ ]	[ ]	[ ]	[ ]
Curvilinear motion	[ ]	[ ]	[ ]	[ ]	[ ]
Tangential and normal components of acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Angular velocity and acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Polar Coordinates					
Polar coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Locus of a polar equation	[ ]	[ ]	[ ]	[ ]	[ ]
Intersection of polar curves	[ ]	[ ]	[ ]	[ ]	[ ]
Angle between the radius vector and tangent	[ ]	[ ]	[ ]	[ ]	[ ]
Differential of arc	[ ]	[ ]	[ ]	[ ]	[ ]
Curvature	[ ]	[ ]	[ ]	[ ]	[ ]
Radical and transverse components of velocity and acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Indeterminate Forms					
Limits	[ ]	[ ]	[ ]	[ ]	[ ]
Rolle's theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Law of the mean	[ ]	[ ]	[ ]	[ ]	[ ]
Cauchy's theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Treatment of indeterminate forms	[ ]	[ ]	[ ]	[ ]	[ ]
Curve Tracing					
Graphs of curves in rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Oblique asymptotes determined by inspection	[ ]	[ ]	[ ]	[ ]	[ ]
Asymptotes to an algebraic curve	[ ]	[ ]	[ ]	[ ]	[ ]
Singular points of algebraic curves	[ ]	[ ]	[ ]	[ ]	[ ]
Summary of curve tracing	[ ]	[ ]	[ ]	[ ]	[ ]
Integration					
Formulas of integration	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of powers	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of exponential functions	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of Trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Transformations of trigonometric integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Integrals giving inverse trigonometric functions	[ ]	[ ]	[ ]	[ ]	[ ]
Additional formulas of integration	[ ]	[ ]	[ ]	[ ]	[ ]
Improper integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Integration by parts	[ ]	[ ]	[ ]	[ ]	[ ]
Algebraic substitutions	[ ]	[ ]	[ ]	[ ]	[ ]
Trigonometric substitutions	[ ]	[ ]	[ ]	[ ]	[ ]
Integration of rational fractions	[ ]	[ ]	[ ]	[ ]	[ ]
Miscellaneous substitutions	[ ]	[ ]	[ ]	[ ]	[ ]
Use of integration tables	[ ]	[ ]	[ ]	[ ]	[ ]
Approximate integration	[ ]	[ ]	[ ]	[ ]	[ ]
Trapezoidal rule	[ ]	[ ]	[ ]	[ ]	[ ]
Simpson's rule	[ ]	[ ]	[ ]	[ ]	[ ]
Area in polar coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Length of a plane curve	[ ]	[ ]	[ ]	[ ]	[ ]
Centroid and moment of inertia of arc	[ ]	[ ]	[ ]	[ ]	[ ]
Area of a surface of revolution	[ ]	[ ]	[ ]	[ ]	[ ]
Volumes of solids with known cross sections	[ ]	[ ]	[ ]	[ ]	[ ]
Average value	[ ]	[ ]	[ ]	[ ]	[ ]
Infinite Series					
Sequences and series	[ ]	[ ]	[ ]	[ ]	[ ]
Convergent and divergent series	[ ]	[ ]	[ ]	[ ]	[ ]
Theorems on convergence	[ ]	[ ]	[ ]	[ ]	[ ]
The integral test	[ ]	[ ]	[ ]	[ ]	[ ]
Comparison tests	[ ]	[ ]	[ ]	[ ]	[ ]
Ratio test	[ ]	[ ]	[ ]	[ ]	[ ]
Alternating series	[ ]	[ ]	[ ]	[ ]	[ ]
Absolute and conditional convergence	[ ]	[ ]	[ ]	[ ]	[ ]
Power series	[ ]	[ ]	[ ]	[ ]	[ ]

1 = Not Covered
2 = Introduced Only
3 = Brief Discussion
4 = Covered in some Depth
5 = Covered in Detail

Expansion of Functions

Topic	1	2	3	4	5
Maclaurin's series	[ ]	[ ]	[ ]	[ ]	[ ]
Algebraic operations with power series	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation and integration of power series	[ ]	[ ]	[ ]	[ ]	[ ]
Approximation formulas derived from power series	[ ]	[ ]	[ ]	[ ]	[ ]
Taylor's series	[ ]	[ ]	[ ]	[ ]	[ ]
Taylor's theorem	[ ]	[ ]	[ ]	[ ]	[ ]

Hyperbolic Functions

Topic	1	2	3	4	5
Definitions of the Hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Identities involving hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives and integrals of hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
The inverse hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Derivatives of the inverse hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Integrals leading to inverse hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Relations between trigonometric and hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]
Geometric interpretation of hyperbolic functions	[ ]	[ ]	[ ]	[ ]	[ ]

Solid Analytic Geometry

Topic	1	2	3	4	5
Rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Distance between two points	[ ]	[ ]	[ ]	[ ]	[ ]
Point on the line joining two points	[ ]	[ ]	[ ]	[ ]	[ ]
Direction of a line	[ ]	[ ]	[ ]	[ ]	[ ]
Angle between two lines	[ ]	[ ]	[ ]	[ ]	[ ]
Locus of a point in space	[ ]	[ ]	[ ]	[ ]	[ ]
Equation of a plane	[ ]	[ ]	[ ]	[ ]	[ ]
Normal equation of a plane	[ ]	[ ]	[ ]	[ ]	[ ]
Planes determined by three conditions	[ ]	[ ]	[ ]	[ ]	[ ]
Equations of a line	[ ]	[ ]	[ ]	[ ]	[ ]
Symmetric equations of a line	[ ]	[ ]	[ ]	[ ]	[ ]
Equation of a surface	[ ]	[ ]	[ ]	[ ]	[ ]
Quadric surfaces	[ ]	[ ]	[ ]	[ ]	[ ]

Partial Differentiation

Topic	1	2	3	4	5
Functions of two or more variables	[ ]	[ ]	[ ]	[ ]	[ ]
Continuity	[ ]	[ ]	[ ]	[ ]	[ ]
Partial derivatives	[ ]	[ ]	[ ]	[ ]	[ ]
Geometric interpretation of partial derivatives	[ ]	[ ]	[ ]	[ ]	[ ]
Partial derivatives of higher order	[ ]	[ ]	[ ]	[ ]	[ ]
Increment and total differential of a function	[ ]	[ ]	[ ]	[ ]	[ ]
Approximations and errors	[ ]	[ ]	[ ]	[ ]	[ ]
Total derivative	[ ]	[ ]	[ ]	[ ]	[ ]
Chain rule for partial derivatives	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation of implicit functions	[ ]	[ ]	[ ]	[ ]	[ ]
Tangent line and normal plane to a curve	[ ]	[ ]	[ ]	[ ]	[ ]
Normal line and tangent plane to a surface	[ ]	[ ]	[ ]	[ ]	[ ]
Maxima and minima	[ ]	[ ]	[ ]	[ ]	[ ]
Differentiation of a definite integral	[ ]	[ ]	[ ]	[ ]	[ ]
Taylor's series for functions of two variables	[ ]	[ ]	[ ]	[ ]	[ ]
Sufficient condition for a maximum or minimum	[ ]	[ ]	[ ]	[ ]	[ ]

Multiple Integrals

Topic	1	2	3	4	5
Double integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Iterated integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Iterated integrals in rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Plane areas by double integration	[ ]	[ ]	[ ]	[ ]	[ ]
Centroid and moment of inertia of a plane area	[ ]	[ ]	[ ]	[ ]	[ ]
Iterated integrals in polar coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Plane areas in polar coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Volumes by double integration	[ ]	[ ]	[ ]	[ ]	[ ]
Volumes in cylindrical coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Areas of curved surfaces	[ ]	[ ]	[ ]	[ ]	[ ]
Triple integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Iterated integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Iterated triple integrals in rectangular coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Volumes by triple integration	[ ]	[ ]	[ ]	[ ]	[ ]
Center of gravity and moment of inertia of a solid	[ ]	[ ]	[ ]	[ ]	[ ]
Triple integrals in cylindrical coordinates	[ ]	[ ]	[ ]	[ ]	[ ]
Triple integrals in spherical coord coordinates	[ ]	[ ]	[ ]	[ ]	[ ]

Differential Equations

Topic	1	2	3	4	5
Solutions of differential equations	[ ]	[ ]	[ ]	[ ]	[ ]
Differential equations of first order and first degree	[ ]	[ ]	[ ]	[ ]	[ ]
Exact differential equations	[ ]	[ ]	[ ]	[ ]	[ ]
Linear equations of the first order	[ ]	[ ]	[ ]	[ ]	[ ]
Equations reducible to linear equations	[ ]	[ ]	[ ]	[ ]	[ ]
Second order equations reducible to first order	[ ]	[ ]	[ ]	[ ]	[ ]
Applications of first order differential equations	[ ]	[ ]	[ ]	[ ]	[ ]
Linear differential equations of order n	[ ]	[ ]	[ ]	[ ]	[ ]
Homogeneous equations with constant coefficients	[ ]	[ ]	[ ]	[ ]	[ ]
Nonhomogemeous equations with constant coefficients	[ ]	[ ]	[ ]	[ ]	[ ]
Applications of linear differential equations	[ ]	[ ]	[ ]	[ ]	[ ]

Vector Analysis

Topic	1	2	3	4	5
Addition of Vectors	[ ]	[ ]	[ ]	[ ]	[ ]
Scalar multiplication of Vectors	[ ]	[ ]	[ ]	[ ]	[ ]
Vector multiplication of Vectors	[ ]	[ ]	[ ]	[ ]	[ ]
Scalar triple product	[ ]	[ ]	[ ]	[ ]	[ ]
Vector triple product	[ ]	[ ]	[ ]	[ ]	[ ]
Derivative of a vector	[ ]	[ ]	[ ]	[ ]	[ ]
The gradient	[ ]	[ ]	[ ]	[ ]	[ ]
The divergence	[ ]	[ ]	[ ]	[ ]	[ ]
The curl of rotation	[ ]	[ ]	[ ]	[ ]	[ ]
Summary of vector differentiation	[ ]	[ ]	[ ]	[ ]	[ ]
Line integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Surface integrals	[ ]	[ ]	[ ]	[ ]	[ ]
Divergence theorem	[ ]	[ ]	[ ]	[ ]	[ ]
Stokes's theorem	[ ]	[ ]	[ ]	[ ]	[ ]

APPENDIX C

ENGINEERING TECHNOLOGY EDUCATION STUDY

Curriculum Survey
CHEMISTRY

Please indicate, by checking the appropriate space, the extent to which each of the following concepts on topics is treated in your syllabus for the General Chemistry course which is offered for engineering technology students. The General Chemistry course for which responses are given should be the one taken by non-majors in case separate courses are offered for majors and non majors. If your course outline normally includes additional topics, please add them at the end of the list.

	Not Covered	Introduced Only	Brief Discussion	Covered in some Depth	Covered in Detail
Classification of matter	[ ]	[ ]	[ ]	[ ]	[ ]
Weight relations, conservation laws	[ ]	[ ]	[ ]	[ ]	[ ]
Physical & Chemical changes	[ ]	[ ]	[ ]	[ ]	[ ]
Chemical notation	[ ]	[ ]	[ ]	[ ]	[ ]
Atomic and Formula Weight	[ ]	[ ]	[ ]	[ ]	[ ]
Chemical equations and Stoichiometry	[ ]	[ ]	[ ]	[ ]	[ ]
Kinds of Elements	[ ]	[ ]	[ ]	[ ]	[ ]
Descriptive Study of certain representative elements	[ ]	[ ]	[ ]	[ ]	[ ]
Binary Compounds	[ ]	[ ]	[ ]	[ ]	[ ]
Ternary Compounds	[ ]	[ ]	[ ]	[ ]	[ ]
Fundamental Particles	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear Reactions	[ ]	[ ]	[ ]	[ ]	[ ]
Natural Radioactivity	[ ]	[ ]	[ ]	[ ]	[ ]
Artificial Radioactivity	[ ]	[ ]	[ ]	[ ]	[ ]
Fission and Fusion	[ ]	[ ]	[ ]	[ ]	[ ]
Periodic Law	[ ]	[ ]	[ ]	[ ]	[ ]
Atomic Structure	[ ]	[ ]	[ ]	[ ]	[ ]
Stable Electron Configurations	[ ]	[ ]	[ ]	[ ]	[ ]
Alkali Metals	[ ]	[ ]	[ ]	[ ]	[ ]
Metals of Groups IIA and IIIA	[ ]	[ ]	[ ]	[ ]	[ ]
Elements of Groups VIA and VIIA	[ ]	[ ]	[ ]	[ ]	[ ]
Transition Elements	[ ]	[ ]	[ ]	[ ]	[ ]
Elements of Groups IVA and VA	[ ]	[ ]	[ ]	[ ]	[ ]
Ionic Bond	[ ]	[ ]	[ ]	[ ]	[ ]
Simple and Complex Ions	[ ]	[ ]	[ ]	[ ]	[ ]
Electrolysis	[ ]	[ ]	[ ]	[ ]	[ ]
Covalent Bond	[ ]	[ ]	[ ]	[ ]	[ ]
Structure of the Hydrogen Molecule	[ ]	[ ]	[ ]	[ ]	[ ]
Other Diatomic Molecules	[ ]	[ ]	[ ]	[ ]	[ ]
Covalent Bonds between Dissimilar Atoms	[ ]	[ ]	[ ]	[ ]	[ ]
Properties of Covalent Compounds	[ ]	[ ]	[ ]	[ ]	[ ]
Solvent-Solute Phenomena	[ ]	[ ]	[ ]	[ ]	[ ]
Molality	[ ]	[ ]	[ ]	[ ]	[ ]
Freezing Point Depression and Boiling Point Elevation Calculations	[ ]	[ ]	[ ]	[ ]	[ ]
Partially Ionic Bonds	[ ]	[ ]	[ ]	[ ]	[ ]
Partially Covalent Bonds	[ ]	[ ]	[ ]	[ ]	[ ]
Electronegativity	[ ]	[ ]	[ ]	[ ]	[ ]
Structure of Partially Ionic-Partially Covalent Compounds	[ ]	[ ]	[ ]	[ ]	[ ]
Dipolar Molecules	[ ]	[ ]	[ ]	[ ]	[ ]

	Not Covered	Introduced Only	Brief Discussion	Covered in some Depth	Covered in Detail
Ionization of Polar Molecules	[ ]	[ ]	[ ]	[ ]	[ ]
Hydrogen Bonding	[ ]	[ ]	[ ]	[ ]	[ ]
Redox Reactions of the Free Elements	[ ]	[ ]	[ ]	[ ]	[ ]
Redox Reactions of Compounds	[ ]	[ ]	[ ]	[ ]	[ ]
Oxidation Numbers	[ ]	[ ]	[ ]	[ ]	[ ]
Balancing Redox Equations	[ ]	[ ]	[ ]	[ ]	[ ]
Activity Series	[ ]	[ ]	[ ]	[ ]	[ ]
Redox Equilibria	[ ]	[ ]	[ ]	[ ]	[ ]
Arrhenius Concept of Acids and Bases	[ ]	[ ]	[ ]	[ ]	[ ]
Bronsted-Lowry Concept of Acids and Bases	[ ]	[ ]	[ ]	[ ]	[ ]
Lewis Concept of Acids and Bases	[ ]	[ ]	[ ]	[ ]	[ ]
Strengths of Acids and Bases	[ ]	[ ]	[ ]	[ ]	[ ]
Hydrolysis of Salts	[ ]	[ ]	[ ]	[ ]	[ ]
Titration	[ ]	[ ]	[ ]	[ ]	[ ]
Normal and Molar Concentration	[ ]	[ ]	[ ]	[ ]	[ ]
Indicators	[ ]	[ ]	[ ]	[ ]	[ ]
Acidic, Basic, and Amphoteric Oxides	[ ]	[ ]	[ ]	[ ]	[ ]
Acid-Base Equilibria	[ ]	[ ]	[ ]	[ ]	[ ]
pH Calculations	[ ]	[ ]	[ ]	[ ]	[ ]
Liquids - Gases - Solutions	[ ]	[ ]	[ ]	[ ]	[ ]
Van der Waals, Ionic, Covalent, and Metallic Solids	[ ]	[ ]	[ ]	[ ]	[ ]
Boyle's Law Calculations	[ ]	[ ]	[ ]	[ ]	[ ]
Charles' Law Calculations	[ ]	[ ]	[ ]	[ ]	[ ]
Ideal Gas Law Calculations	[ ]	[ ]	[ ]	[ ]	[ ]
Forms of Energy	[ ]	[ ]	[ ]	[ ]	[ ]
Specific Heat	[ ]	[ ]	[ ]	[ ]	[ ]
Heat of Fusion	[ ]	[ ]	[ ]	[ ]	[ ]
Heat of Vaporization	[ ]	[ ]	[ ]	[ ]	[ ]
Kinetic-Molecular Theory	[ ]	[ ]	[ ]	[ ]	[ ]
Bond Energies	[ ]	[ ]	[ ]	[ ]	[ ]
Heat of Reaction	[ ]	[ ]	[ ]	[ ]	[ ]
Activation Energy	[ ]	[ ]	[ ]	[ ]	[ ]
Free Energy	[ ]	[ ]	[ ]	[ ]	[ ]
Enthalpy and Entrophy	[ ]	[ ]	[ ]	[ ]	[ ]
Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Aliphatic Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Aromatic Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Reactions of Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Functionally Substituted Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Reactions of Substituted Hydrocarbons	[ ]	[ ]	[ ]	[ ]	[ ]
Ionic Organic Mechanisms	[ ]	[ ]	[ ]	[ ]	[ ]
Free Radical Organic Mechanisms	[ ]	[ ]	[ ]	[ ]	[ ]
Sugars and Polysaccharides	[ ]	[ ]	[ ]	[ ]	[ ]
Fats	[ ]	[ ]	[ ]	[ ]	[ ]
Amino Acids and Proteins	[ ]	[ ]	[ ]	[ ]	[ ]
Vitamins and Alkaloids	[ ]	[ ]	[ ]	[ ]	[ ]

APPENDIX D

ENGINEERING TECHNOLOGY EDUCATION STUDY

Curriculum Survey
PHYSICS

Please indicate, by checking the appropriate space, the extent to which each of the following concepts is treated in your syllabus for the Physics course which is offered for students in engineering technology curricula. If your course outline normally includes additional topics, please add them at the end of the list.

1 = Not Covered
2 = Introduced Only
3 = Brief Discussion
4 = Covered in some Depth
5 = Covered in Detail

Mechanics	1	2	3	4	5
Units and Systems of Measurement	[ ]	[ ]	[ ]	[ ]	[ ]
Vector quantities	[ ]	[ ]	[ ]	[ ]	[ ]
Representation of Vector quantities	[ ]	[ ]	[ ]	[ ]	[ ]
Vector addition	[ ]	[ ]	[ ]	[ ]	[ ]
Vector subtraction	[ ]	[ ]	[ ]	[ ]	[ ]
Resolution of Vectors	[ ]	[ ]	[ ]	[ ]	[ ]
Component method of Vector addition	[ ]	[ ]	[ ]	[ ]	[ ]
Constant, Instantaneous, and Average Speed	[ ]	[ ]	[ ]	[ ]	[ ]
Speed and velocity	[ ]	[ ]	[ ]	[ ]	[ ]
Acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Kinematics equations	[ ]	[ ]	[ ]	[ ]	[ ]
Falling bodies	[ ]	[ ]	[ ]	[ ]	[ ]
Motion in a vertical plane	[ ]	[ ]	[ ]	[ ]	[ ]
Projectile and Rocket flight	[ ]	[ ]	[ ]	[ ]	[ ]
Laws of motion	[ ]	[ ]	[ ]	[ ]	[ ]
First law of motion	[ ]	[ ]	[ ]	[ ]	[ ]
Second law of motion	[ ]	[ ]	[ ]	[ ]	[ ]
Third law of motion	[ ]	[ ]	[ ]	[ ]	[ ]
Inertia and mass	[ ]	[ ]	[ ]	[ ]	[ ]
Force and motion	[ ]	[ ]	[ ]	[ ]	[ ]
Mass and weight	[ ]	[ ]	[ ]	[ ]	[ ]
Sliding friction	[ ]	[ ]	[ ]	[ ]	[ ]
Coefficient of friction	[ ]	[ ]	[ ]	[ ]	[ ]
Static friction	[ ]	[ ]	[ ]	[ ]	[ ]
Rolling friction	[ ]	[ ]	[ ]	[ ]	[ ]
Fluid friction	[ ]	[ ]	[ ]	[ ]	[ ]
Equilibrium of a particle	[ ]	[ ]	[ ]	[ ]	[ ]
Torque	[ ]	[ ]	[ ]	[ ]	[ ]
Center of gravity	[ ]	[ ]	[ ]	[ ]	[ ]
Uniform circular motion	[ ]	[ ]	[ ]	[ ]	[ ]
Centripetal acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Centripetal force	[ ]	[ ]	[ ]	[ ]	[ ]
Banked turns	[ ]	[ ]	[ ]	[ ]	[ ]
Centrifugal force	[ ]	[ ]	[ ]	[ ]	[ ]
Gravitation	[ ]	[ ]	[ ]	[ ]	[ ]
Gravitational field	[ ]	[ ]	[ ]	[ ]	[ ]
Energy, definitions	[ ]	[ ]	[ ]	[ ]	[ ]
Work	[ ]	[ ]	[ ]	[ ]	[ ]
Power	[ ]	[ ]	[ ]	[ ]	[ ]
Power measurement	[ ]	[ ]	[ ]	[ ]	[ ]
Kinetic energy	[ ]	[ ]	[ ]	[ ]	[ ]
Potential energy	[ ]	[ ]	[ ]	[ ]	[ ]
Conservation of energy	[ ]	[ ]	[ ]	[ ]	[ ]
Momentum and impulse	[ ]	[ ]	[ ]	[ ]	[ ]
Conservation of momentum	[ ]	[ ]	[ ]	[ ]	[ ]
Collisions	[ ]	[ ]	[ ]	[ ]	[ ]
Angular measurement	[ ]	[ ]	[ ]	[ ]	[ ]
Angular velocity	[ ]	[ ]	[ ]	[ ]	[ ]
Angular acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Kinematics of Angular motion	[ ]	[ ]	[ ]	[ ]	[ ]
Rotational kinetic energy	[ ]	[ ]	[ ]	[ ]	[ ]
Moment of inertia	[ ]	[ ]	[ ]	[ ]	[ ]
Torque and angular acceleration	[ ]	[ ]	[ ]	[ ]	[ ]
Angular momentum	[ ]	[ ]	[ ]	[ ]	[ ]
Simple Machines	[ ]	[ ]	[ ]	[ ]	[ ]
Mechanical advantage	[ ]	[ ]	[ ]	[ ]	[ ]
Efficiency	[ ]	[ ]	[ ]	[ ]	[ ]
Density	[ ]	[ ]	[ ]	[ ]	[ ]

	1	2	3	4	5
Elasticity	[ ]	[ ]	[ ]	[ ]	[ ]
Young's modulus	[ ]	[ ]	[ ]	[ ]	[ ]
Shear modulus	[ ]	[ ]	[ ]	[ ]	[ ]
Bulk modulus	[ ]	[ ]	[ ]	[ ]	[ ]
Pressure	[ ]	[ ]	[ ]	[ ]	[ ]
Hydraulic press	[ ]	[ ]	[ ]	[ ]	[ ]
Pressure and depth	[ ]	[ ]	[ ]	[ ]	[ ]
Archimedes' principle	[ ]	[ ]	[ ]	[ ]	[ ]
Fluid flow	[ ]	[ ]	[ ]	[ ]	[ ]
Bernoulli's equation	[ ]	[ ]	[ ]	[ ]	[ ]
Elastic potential energy	[ ]	[ ]	[ ]	[ ]	[ ]
Simple harmonic motion	[ ]	[ ]	[ ]	[ ]	[ ]
The pendulum	[ ]	[ ]	[ ]	[ ]	[ ]
Kinematics of vibratory motion	[ ]	[ ]	[ ]	[ ]	[ ]
Wave Motion, Acoustics					
Water waves	[ ]	[ ]	[ ]	[ ]	[ ]
Longitudinal and transverse waves	[ ]	[ ]	[ ]	[ ]	[ ]
Wave speed and energy	[ ]	[ ]	[ ]	[ ]	[ ]
Standing waves	[ ]	[ ]	[ ]	[ ]	[ ]
Resonance	[ ]	[ ]	[ ]	[ ]	[ ]
Sound	[ ]	[ ]	[ ]	[ ]	[ ]
Musical Sounds	[ ]	[ ]	[ ]	[ ]	[ ]
Acoustical attenuation	[ ]	[ ]	[ ]	[ ]	[ ]
Supersonic waves	[ ]	[ ]	[ ]	[ ]	[ ]
Doppler effect	[ ]	[ ]	[ ]	[ ]	[ ]
Heat					
Temperature	[ ]	[ ]	[ ]	[ ]	[ ]
Heat	[ ]	[ ]	[ ]	[ ]	[ ]
Specific heat capacity	[ ]	[ ]	[ ]	[ ]	[ ]
Change of state	[ ]	[ ]	[ ]	[ ]	[ ]
Calorimetry	[ ]	[ ]	[ ]	[ ]	[ ]
Mechanical equivalent of heat	[ ]	[ ]	[ ]	[ ]	[ ]
Thermal expansion	[ ]	[ ]	[ ]	[ ]	[ ]
Volume expansion	[ ]	[ ]	[ ]	[ ]	[ ]
Boyle's law	[ ]	[ ]	[ ]	[ ]	[ ]
Charles's law	[ ]	[ ]	[ ]	[ ]	[ ]
Ideal gas law	[ ]	[ ]	[ ]	[ ]	[ ]
Kinetic theory of gases	[ ]	[ ]	[ ]	[ ]	[ ]
Kinetic theory of matter	[ ]	[ ]	[ ]	[ ]	[ ]
First law of thermodynamics	[ ]	[ ]	[ ]	[ ]	[ ]
Second law of thermodynamics	[ ]	[ ]	[ ]	[ ]	[ ]
Carnot engine	[ ]	[ ]	[ ]	[ ]	[ ]
Carnot efficiency	[ ]	[ ]	[ ]	[ ]	[ ]
Steam engines	[ ]	[ ]	[ ]	[ ]	[ ]
Internal combustion engines	[ ]	[ ]	[ ]	[ ]	[ ]
Statistical mechanics	[ ]	[ ]	[ ]	[ ]	[ ]
Conduction	[ ]	[ ]	[ ]	[ ]	[ ]
Convection	[ ]	[ ]	[ ]	[ ]	[ ]
Radiation	[ ]	[ ]	[ ]	[ ]	[ ]
The refrigerator	[ ]	[ ]	[ ]	[ ]	[ ]
Thermodynamics of refrigeration	[ ]	[ ]	[ ]	[ ]	[ ]
Light, Optics					
Huygen's principle	[ ]	[ ]	[ ]	[ ]	[ ]
Reflection	[ ]	[ ]	[ ]	[ ]	[ ]
Plane mirror	[ ]	[ ]	[ ]	[ ]	[ ]
Concave mirror	[ ]	[ ]	[ ]	[ ]	[ ]
Convex mirror	[ ]	[ ]	[ ]	[ ]	[ ]
Image formation	[ ]	[ ]	[ ]	[ ]	[ ]
Mirror equation	[ ]	[ ]	[ ]	[ ]	[ ]
Magnification	[ ]	[ ]	[ ]	[ ]	[ ]
Spherical aberration	[ ]	[ ]	[ ]	[ ]	[ ]
Snell's law	[ ]	[ ]	[ ]	[ ]	[ ]

1 = Not Covered
2 = Introduced Only
3 = Brief Discussion
4 = Covered in some Depth
5 = Covered in Detail

	1	2	3	4	5
Index of refraction	[ ]	[ ]	[ ]	[ ]	[ ]
Apparent depth	[ ]	[ ]	[ ]	[ ]	[ ]
Total internal reflection	[ ]	[ ]	[ ]	[ ]	[ ]
Lenses	[ ]	[ ]	[ ]	[ ]	[ ]
Image formation	[ ]	[ ]	[ ]	[ ]	[ ]
The lens equation	[ ]	[ ]	[ ]	[ ]	[ ]
The eye	[ ]	[ ]	[ ]	[ ]	[ ]
The microscope	[ ]	[ ]	[ ]	[ ]	[ ]
The telescope	[ ]	[ ]	[ ]	[ ]	[ ]
Lens aberrations	[ ]	[ ]	[ ]	[ ]	[ ]
Diffraction	[ ]	[ ]	[ ]	[ ]	[ ]
The double slit	[ ]	[ ]	[ ]	[ ]	[ ]
Color, Spectra and Spectrometry	[ ]	[ ]	[ ]	[ ]	[ ]
Diffraction grating	[ ]	[ ]	[ ]	[ ]	[ ]
Polarization	[ ]	[ ]	[ ]	[ ]	[ ]

Electricity and Magnetism

	1	2	3	4	5
Electric charge	[ ]	[ ]	[ ]	[ ]	[ ]
Coulomb's law	[ ]	[ ]	[ ]	[ ]	[ ]
Multiple charges	[ ]	[ ]	[ ]	[ ]	[ ]
The electric field	[ ]	[ ]	[ ]	[ ]	[ ]
Electric field of a point charge	[ ]	[ ]	[ ]	[ ]	[ ]
Electric lines of force	[ ]	[ ]	[ ]	[ ]	[ ]
Potential difference	[ ]	[ ]	[ ]	[ ]	[ ]
Electric current	[ ]	[ ]	[ ]	[ ]	[ ]
Ohm's law	[ ]	[ ]	[ ]	[ ]	[ ]
Resistivity	[ ]	[ ]	[ ]	[ ]	[ ]
Resistors in combination	[ ]	[ ]	[ ]	[ ]	[ ]
Electrical power	[ ]	[ ]	[ ]	[ ]	[ ]
Electromotive force	[ ]	[ ]	[ ]	[ ]	[ ]
Kirchhoff's rules	[ ]	[ ]	[ ]	[ ]	[ ]
Ionization and recombination	[ ]	[ ]	[ ]	[ ]	[ ]
Polar molecules	[ ]	[ ]	[ ]	[ ]	[ ]
Electrolysis	[ ]	[ ]	[ ]	[ ]	[ ]
Electrochemical equivalent and electrodeposition	[ ]	[ ]	[ ]	[ ]	[ ]
Chemical sources of electric energy	[ ]	[ ]	[ ]	[ ]	[ ]
Dry batteries	[ ]	[ ]	[ ]	[ ]	[ ]
Storage batteries	[ ]	[ ]	[ ]	[ ]	[ ]
Fuel cells	[ ]	[ ]	[ ]	[ ]	[ ]
Capacitance	[ ]	[ ]	[ ]	[ ]	[ ]
Energy of a charged capacitor	[ ]	[ ]	[ ]	[ ]	[ ]
Electric energy density	[ ]	[ ]	[ ]	[ ]	[ ]
Dielectric constant	[ ]	[ ]	[ ]	[ ]	[ ]
Charging a capacitor	[ ]	[ ]	[ ]	[ ]	[ ]
Oersted's experiment	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic induction	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic field of a current	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic properties of matter	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic intensity	[ ]	[ ]	[ ]	[ ]	[ ]
Hysteresis	[ ]	[ ]	[ ]	[ ]	[ ]
Force on a current	[ ]	[ ]	[ ]	[ ]	[ ]
Force between two currents	[ ]	[ ]	[ ]	[ ]	[ ]
Behavior of charged particles in a magnetic field	[ ]	[ ]	[ ]	[ ]	[ ]
Force on a current loop	[ ]	[ ]	[ ]	[ ]	[ ]
Galvanometer	[ ]	[ ]	[ ]	[ ]	[ ]
Ammeter	[ ]	[ ]	[ ]	[ ]	[ ]
Voltmeter	[ ]	[ ]	[ ]	[ ]	[ ]
DC electric motor	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic poles	[ ]	[ ]	[ ]	[ ]	[ ]
Faraday's law	[ ]	[ ]	[ ]	[ ]	[ ]
The betatron	[ ]	[ ]	[ ]	[ ]	[ ]
Moving wire in a magnetic field	[ ]	[ ]	[ ]	[ ]	[ ]
AC-generator	[ ]	[ ]	[ ]	[ ]	[ ]
DC-generator	[ ]	[ ]	[ ]	[ ]	[ ]
Back emf	[ ]	[ ]	[ ]	[ ]	[ ]
Transformer	[ ]	[ ]	[ ]	[ ]	[ ]
Inductance	[ ]	[ ]	[ ]	[ ]	[ ]
Solenoid	[ ]	[ ]	[ ]	[ ]	[ ]
Growth and decay of current	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic potential energy	[ ]	[ ]	[ ]	[ ]	[ ]
Magnetic energy density	[ ]	[ ]	[ ]	[ ]	[ ]
Electrical oscillations	[ ]	[ ]	[ ]	[ ]	[ ]
Effective current and voltage	[ ]	[ ]	[ ]	[ ]	[ ]
Phase relations	[ ]	[ ]	[ ]	[ ]	[ ]
Inductive reactance	[ ]	[ ]	[ ]	[ ]	[ ]
Capacitive reactance	[ ]	[ ]	[ ]	[ ]	[ ]
Impedance	[ ]	[ ]	[ ]	[ ]	[ ]
Resonance	[ ]	[ ]	[ ]	[ ]	[ ]
Power in AC-circuits	[ ]	[ ]	[ ]	[ ]	[ ]
Maxwell's hypothesis	[ ]	[ ]	[ ]	[ ]	[ ]
Electromagnetic waves	[ ]	[ ]	[ ]	[ ]	[ ]
Varieties of electromagnetic waves	[ ]	[ ]	[ ]	[ ]	[ ]
Electromagnetic waves in communications	[ ]	[ ]	[ ]	[ ]	[ ]
Radiation pressure	[ ]	[ ]	[ ]	[ ]	[ ]

Modern Physics

	1	2	3	4	5
Frames of reference	[ ]	[ ]	[ ]	[ ]	[ ]
Special theory of relativity	[ ]	[ ]	[ ]	[ ]	[ ]
Relativity and mass	[ ]	[ ]	[ ]	[ ]	[ ]
Mass and energy	[ ]	[ ]	[ ]	[ ]	[ ]
Photoelectric effect	[ ]	[ ]	[ ]	[ ]	[ ]
Quantum theory of light	[ ]	[ ]	[ ]	[ ]	[ ]
X-rays	[ ]	[ ]	[ ]	[ ]	[ ]
Matter waves	[ ]	[ ]	[ ]	[ ]	[ ]
Uncertainty principle	[ ]	[ ]	[ ]	[ ]	[ ]
Causality	[ ]	[ ]	[ ]	[ ]	[ ]
The nuclear model of the atom	[ ]	[ ]	[ ]	[ ]	[ ]
Electron orbits	[ ]	[ ]	[ ]	[ ]	[ ]
Atomic spectra	[ ]	[ ]	[ ]	[ ]	[ ]
Bohr atom	[ ]	[ ]	[ ]	[ ]	[ ]
Energy levels and spectra	[ ]	[ ]	[ ]	[ ]	[ ]
Atomic excitation	[ ]	[ ]	[ ]	[ ]	[ ]
Quantum theory of the atom	[ ]	[ ]	[ ]	[ ]	[ ]
Electron spin	[ ]	[ ]	[ ]	[ ]	[ ]
Periodic law	[ ]	[ ]	[ ]	[ ]	[ ]
Atomic structure	[ ]	[ ]	[ ]	[ ]	[ ]
Ionic binding	[ ]	[ ]	[ ]	[ ]	[ ]
Covalent binding	[ ]	[ ]	[ ]	[ ]	[ ]
Polar molecules	[ ]	[ ]	[ ]	[ ]	[ ]
Structure of solids	[ ]	[ ]	[ ]	[ ]	[ ]
Van der Waals bonds	[ ]	[ ]	[ ]	[ ]	[ ]
Metallic bond	[ ]	[ ]	[ ]	[ ]	[ ]
Energy bands	[ ]	[ ]	[ ]	[ ]	[ ]
Impurity semiconductors	[ ]	[ ]	[ ]	[ ]	[ ]
Semiconductor devices	[ ]	[ ]	[ ]	[ ]	[ ]
Ferromagnetism	[ ]	[ ]	[ ]	[ ]	[ ]
Mass spectrometer	[ ]	[ ]	[ ]	[ ]	[ ]
Nucleons	[ ]	[ ]	[ ]	[ ]	[ ]
Isotopes	[ ]	[ ]	[ ]	[ ]	[ ]
Binding energy	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear forces	[ ]	[ ]	[ ]	[ ]	[ ]
Radioactivity	[ ]	[ ]	[ ]	[ ]	[ ]
Half-life	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear reactions	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear fission	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear reactors	[ ]	[ ]	[ ]	[ ]	[ ]
Nuclear fusion	[ ]	[ ]	[ ]	[ ]	[ ]
The neutrino	[ ]	[ ]	[ ]	[ ]	[ ]
Antiparticles	[ ]	[ ]	[ ]	[ ]	[ ]

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APPENDIX E

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Suite 400—One Dupont Circle, Washington, D. C. 20036

STUDENT INFORMATION

TO STUDENTS ENROLLED IN TECHNOLOGICAL CURRICULA:

The American Society for Engineering Education (ASEE) is conducting a national study of technological education. Information is needed from students in engineering, pre-engineering, industrial technology, engineering technology, and other technical programs. You are being asked to participate in this study by providing responses to the questions below. The information you supply will assist ASEE in its study and will be greatly appreciated.

Your answers will be kept strictly **confidential**, and you will not be personally identified in any way. Do **not** sign this questionnaire.

1 Age______ 2 Sex______ 3 Marital Status______

4 Name of school you now attend ______

5 Registration status (check one) Full-Time ☐ Part-Time ☐

6 Did you attend any other colleges previously? ______ If so, please name them ______

7. What is your present major? ______

8. What previous majors, (if any) had you selected? ______

9. If you had any changes of major, what were the reasons for the change?

10 What is your present grade point average in all subjects? (Please use the "four-point" scale, i e, A = 4, B = 3, C = 2, D = 1) ______

11 Basis of college admission (check one)

a Graduation from high school ☐

b General Education Development test scores or similar equivalency ☐

c Other ☐

12 How many years of each of the following subjects did you have in high school?

a. Mathematics ______

b Physics ______

c Chemistry ______

d Drafting ______

e Industrial Arts ______

f Vocational Education ______

g Technical Education ______

13 What was your rank in your high school class? (Check one)

a Upper Quarter ☐

b Second Quarter ☐

c Third Quarter ☐

d Lower Quarter ☐

e Unknown ☐

15 What are your immediate plans upon graduation from the institution in which you are now enrolled? (Check one explain where needed)

a Seek employment ☐

b. Continue schooling ☐ Where? ______ Major? ______

c Military service ☐

d. Other (Please explain) ______

______

______

______

______

16 What, presently, is your career objective? (Professional or technical employment, management, teaching, operate your own business, etc.)

______

______

______

______

17 How confident are you that the career objective named in item 16 is the one you really want?

a Positive ☐

b Reasonably certain ☐

c Moderately certain ☐

d Not sure, this is a tentative choice only ☐

18 Approximately when in life did you first decide on your career objective?

______

______

19 Who or what influenced you in making your career decision? (Family, high school counselor, work experience, friends, personal interest, etc.)

______

______

______

20 Why did you select the school you are now attending? (Its location, its costs, recommendations or friends, reputation, etc.) ______

______

______

______

21. In you opinion, how well is the program of studies at your school preparing you for your intended career? (Check on and comment on any special strengths or weaknesses you perceive)

a. Excellently ☐ b Adequately ☐ c Inadequately ☐

Comment ______

______

22 How do you classify your home location? (Check one)

a Farm or rural area ☐

b Small Town ☐

c Large Town ☐

d Small City ☐

e Large City ☐

f Major Metropolitan Area ☐

23 If you could choose the environment in which you work, which of the "home location" classifications of question 22 would be

a Your first choice? ______

b Your second choice? ______

c The least preferred? ______

24 What is (or was) your father's occupation? ______

25 In which of the following monthly income brackets do (or did) your parents belong? (Check one)

a Less than $400 ☐

b $ 400 $ 600 ☐

c $ 600 - $ 800 ☐

d $ 800 - $1 000 ☐

e $1 000 - $1,200 ☐

f $1 200 $1 500 ☐

g More than $1 500 ☐

27 Approximately what percentage of your college expenses come from the following sources?

a Family ______

b Personal Funds ______

c Veterans Benefits ______

d Loans ______

e Scholarships or Grants ______

f Other ______ Please explain ______

______

______

______

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Suite 400—One Dupont Circle, Washington, D. C. 20036

GRADUATE INFORMATION

TO GRADUATES OF ENGINEERING TECHNOLOGY CURRICULA:

The American Society for Engineering Education (ASEE) is making a national study of engineering technology education. You, as a graduate of an engineering technology curriculum, can contribute importantly to this national study by providing responses to the questions following. All information you supply will be strictly **confidential**, you will **not** be personally identified in any way. Please complete the questionnaire as promptly as possible and return it in the postage-paid envelope provided. Do **not** sign the questionnaire.

1 What is your job title? ____________

2 From what curriculum did you graduate? ____________

3 When did you graduate? Month ____________ Year ____________

4 How many different job titles (including the current one) have you held since graduation? ____________

5 By how many different firms have you been employed? ____________

6 If you are salaried or self-employed what is your present monthly salary? (Check one)

- a Less than $500 ☐
- b. $500 - $600 ☐
- c $601 - $700 ☐
- d $701 - $800 ☐
- e $801 - $1,000 ☐
- f $1,001 - $1,200 ☐
- g. Over $1,200 ☐

7 If you are an hourly employee, what is your present hourly base pay? (Check one)

- a. Less than $2 50 ☐
- b $2.50 - $3 00 ☐
- c $3 01 - $4.00 ☐
- d, $4 01 - $5 00 ☐
- e $5 01 - $6 00 ☐
- f. Over $6 00 ☐

8. What is your present age? ____________

9 Have you had any educational or training experiences since graduation? Mark each item

	Yes	No
In-service or on-the-job training provided by employer	☐	☐
Courses in public or private schools arranged for and paid for by your employer	☐	☐
Courses in public or private schools selected by you but paid for—wholly or in part—by your employer	☐	☐
Courses in public or private schools at your own choice and expense	☐	☐

10 What was the purpose of the education or training listed in Item 9? (Mark each response which applied)

- a. Orientation and instruction in company policy ☐
- b Acquiring knowledge directly needed on job ☐
- c. Acquiring skills directly needed on job ☐
- d. Preparation for advancement to a higher position ☐
- e Expectation of seeking another position and employer ☐
- f Self-improvement only ☐
- g Other. Please explain ____________

11 When did you decide to enter your present career?

- a. Before high school ☐
- b During high school ☐
- c During college ☐
- d. While employed elsewhere ☐
- e. Other. Please explain ____________

12 What major reason(s) influenced you in your career decisions? (Mark all that apply)

- a You were influenced by your father or other members of your family who were in similar occupations ☐
- b You were influenced by someone, other than a relative, in this occupation ☐
- c You were influenced by a high school teacher or counselor ☐
- d You developed an interest while in another job ☐
- e You developed an interest from newspaper, magazine, radio or television articles or advertisements ☐
- f. Other Please explain ____________

13 What influenced you in your choice of school in preparing for this career? (Mark all that apply)

- a Location ☐
- b Tuition and fees ☐
- c Advice from parents ☐
- d Advice from high school counselor ☐
- e information from friends ☐
- f Publications of the institution ☐
- g Other. Please explain ____________

14 In your opinion, how well did your experience at your school prepare you for your employment? Please comment on any special strengths and weaknesses of your program as you now see it.

a For your first employment	b For your present employment
Excellently ☐	Excellently ☐
Adequately ☐	Adequately ☐
Inadequately ☐	Inadequately ☐

Comments ____________

15 Please study carefully the definitions of job activities at the back of this questionnaire and then, complete the table on the following page as it relates to your present job Admittedly, the list of activities is long, however, your responses here will furnish highly important data of fundamental significance both to the Engineering Technology Education Study and to the institution from which you graduated In the middle five columns of the table, a check-mark in the appropriate square is all that is needed In the last column of the table, enter a number from 1 to 40 as an estimate of the hours per week spent in the major job activities, you need to make entries only for those activities which you identified as being performed "about once per week" or "daily or nearly so."

JOB ACTIVITIES FOR ENGINEERING TECHNICIANS

ANALYSIS: Using mathematical expressions for predicting characteristics of machines, equipment, circuits, structures, or materials.

BUILD THINGS: Building models, experimental machines, structures, circuits, equipment, cables, parts, or components using a variety of hand and machine tools.

CALIBRATION AND ADJUSTMENT: Calibrating and adjusting instruments, machines, or equipment in order to obtain acceptable limits of operation.

CHECK DRAWINGS: Examining drawings done by others and checking for errors.

COMMUNICATIONS: Observing and reporting pertinent activities from one area of your company to another, keeping each area informed of the other's activities.

COORDINATION: Assisting in the solution of problems which are shared by two or more activities, such as engineering department and assembly line or construction site and home office

COMPANY TRAINING: Attending training sessions or special schools as part of the job.

COST ESTIMATING: Estimating costs for materials, labor, equipment, equipment installation, and general expenses for a job.

CUSTOMER SERVICE: Following up on complaints and attempting to satisfy a customer

DATA RECORDING: Recording test data, possibly including a sketch of the test set-up.

DERIVATION: Deriving mathematical expressions for predicting characteristics of machines, equipment, circuits, structures, or materials

DESIGN: Planning, performing calculations, and providing sketches of structures, machines, equipment, circuits, components, parts, or tools to satisfy specifications on size, weight, function, condition of operation, or performance characteristics.

DESIGN ASSISTANCE: Assisting the design leader by performing calculations, obtaining handbook data, determining standard components and parts, or making sketches

DRAFTING—DESIGN: Developing and drawing plans including layout, assembly, dimensions, tolerances, and materials for structures, processes, machines, equipment, components, parts or tools to satisfy specifications on size, weight, function, conditions of operation, or performance characteristics.

DRAFTING—DETAIL: Preparing or modifying drawings of actual equipment, machines, or structures, from design or layout drawings, sketches or from on-site measurements.

DRAFTING—LAYOUT: Planning and drawing the arrangement of parts, determining dimensions, tolerances, or component values using design sketches or calculations.

EVALUATION: Interpreting test data by making calculations to compare actual performance characteristics with desired or expected performance characteristics.

EXPEDITING: Keeping records which show the progress of a job. Scheduling the arrival of materials, equipment, or tools so the job can progress without delay.

EXPERIMENTATION: Using fundamental physical laws and relationships to determine new materials or methods that can be used to improve technological practices

INSPECTION—MAINTENANCE: Inspecting machines, equipment, or structures to determine need for maintenance such as oiling, painting, adjusting, calibrating, repair, or replacement.

INSPECTION—QUALITY CONTROL: Inspecting materials, components, machines, equipment, circuits, or structures in order to verify the quality or conformance with specifications.

INSTALLATION: Installing machines, equipment, or structures according to layout and assembly drawings and installation instructions.

INSTRUMENTATION: Specifying the test equipment, fixtures, and procedures required for testing machines, structures, circuits, equipment, components, parts, or materials

MANUFACTURING: Making, processing or assembling parts in the production of structures, machines, circuits, or equipment.

MAPPING: Making topographical maps from survey data or from aerial photographs.

MARKETING AND SALES: Consulting with potential customers, showing the capability of your equipment, machines, or products in solving their problems.

MATERIALS TESTING: Testing samples of materials such as metals, plastics, ceramics, wood, concrete, asphalt, sand, or rock according to a standard procedure.

METHODS—PRODUCTION: Determining how parts of machines, structures, or equipment should be made and assembled.

METHODS—QUALITY CONTROL: Developing methods for inspection, testing, and evaluation of materials, components, circuits, equipment, machines or structures, either manufactured or purchased by your company.

MODIFICATION: Altering machines, structures, circuits, equipment, or components using a variety of hand or machine tools.

MODIFICATION—RECOMMENDING: Making recommendations for changes in the design of machines, structures, circuits, equipment, or components.

OPERATING: Operating complex equipment or machines which require a special operator because of their complexity.

PERFORMANCE TESTING: Testing machines, structures, circuits, equipment, or components.

PLANNING AND SCHEDULING: Planning and scheduling the work of others considering factors like availability of materials and manpower, capacity of facilities, sequence of operations, and reasonable time limits

PLANT LAYOUT: Planning and drawing the arrangement of spaces, equipment, or machines for a building, portion of a building, or process.

PROCESS CONTROL: Adjusting controls to regulate a continuous flow process in order to meet quality and safety standards.

PROGRAMMING: Translating mathematical expressions or numerical data into program language statements, electrical equivalents, or coded information in order to operate tape controlled machines, computers, or data processing equipment.

PURCHASING: Purchasing materials, equipment, standard parts, or special items, specifying the exact requirements the company you are buying from must meet

QUANTITY ESTIMATING: Estimating the quantity of materials required to build components, equipment, machines or structures

RELIABILITY: Determining reliability data, such as life expectancy or dependability, for structures, machines, circuits, equipment, components, or parts

REPAIR: Replacing bad or worn parts and assemblies in instruments, machines, or equipment

REPORT WRITING: Summarizing job activities, for instance, a report on a test could include apparatus used, procedures followed, test data, calculations comparing actual with expected performance, curves, and charts

SPECIFICATION WRITING: Preparing documents which specify the materials and components satisfactory for use in products or structures produced by your company

SUPERVISING: Telling others what to do and evaluating their performance.

SURVEYING—INSTRUMENT MAN: Setting-up and operating surveying equipment, such as alidades, engineer's levels, or transits, and keeping notes, sketches, and records of work performed.

SURVEYING—RODMAN: Holding surveying rods at points designated by the instrument man, marking points with elevations, making measurements, and performing miscellaneous duties as directed

TECHNICAL PUBLICATION: Writing or revising instruction manuals that include information like theory of operation, maintenance procedures, and trouble-shooting techniques

TRAINING: Instructing others in the use or maintenance of machines, instruments, or equipment or in fundamental concepts relating to these machines, instruments, or equipment.

TROUBLESHOOTING: Determining why machines, circuits, equipment, or structures are not performing like expected.

VERBAL REPORTS: Describing job activities, for instance, reporting on a test could include test set-up used, procedure followed, results obtained, and problems encountered

WRITE PROPOSALS: Preparing written descriptions and cost estimates of ways to satisfy needs expressed by customers.

WRITING CHANGE NOTICES: Writing instructions which describe design modifications to machines, structures, circuits, or equipment

WRITING STANDARD PRACTICES: Preparing written descriptions of methods, processes, or procedures in order to establish standard practices.

Job Activity	Frequency of Performance of Activity					
	Never	Less than once per month	About once per month	About once per week	Daily or nearly so	Hours per week normally devoted to this activity
Analysis						
Building things						
Calibration & Adjustment						
Check Drawing						
Communications						
Coordination						
Company Training						
Cost Estimating						
Customer Service						
Data Recording						
Derivation						
Design						
Design Assistance						
Drafting, Design						
Drafting, Detail						
Drafting, Layout						
Evaluation						
Expediting						
Experimentation						
Inspection, Maintenance						
Inspection, Quality Control						
Installation						
Instrumentation						
Manufacturing						
Mapping						
Marketing & Sales						
Material Testing						
Methods, Production						
Methods, Quality Control						
Modifications, Making						
Modifications, Recommending						
Operating						
Performance Testing						
Planning & Scheduling						
Plant Layout						
Process Control						
Programming						
Purchasing						
Quantity Estimating						
Reliability						
Repair						
Supervising						
Surveying, Instrument Man						
Surveying, Rod Man						
Technical Publication						
Training						
Troubleshooting						
Verbal Reports						
Writing Reports						
Writing Proposals						
Writing Change Notices						
Writing Standard Practices						
Writing Specifications						

APPENDIX G

ESTIMATES OF ENROLLMENTS AND GRADUATES, ENGINEERING TECHNOLOGY PROGRAMS ACADEMIC YEAR 1969-70

	Associate Degree Programs		Baccalaureate Programs	
	Estimated Enrollments	Estimated Graduates	Estimated Enrollments	Estimated Graduates
Alabama	243	63	280	58
Alaska	121	9	0	0
Arizona	2,078	344	743	186
Arkansas	201	55	8	2
California	10,336	2,582	1,276	344
Colorado	924	272	326	79
Connecticut	2,346	641	0	0
Delaware	133	28	0	0
D.C.	385	106	0	0
Florida	4,068	798	81	13
Georgia	979	276	493	55
Hawaii	104	28	64	16
Idaho	213	59	0	0
Illinois	3,172	917	2,192	470
Indiana	4,088	1,111	525	418
Iowa	1,453	414	0	0
Kansas	579	137	818	170
Kentucky	251	36	236	27
Louisiana	295	81	950	321
Maine	354	117	0	0
Maryland	975	230	366	156
Massachusetts	5,230	1,745	478	70
Michigan	3,920	944	1,322	249
Minnesota	430	96	198	84
Mississippi	480	128	42	22
Missouri	1,595	391	322	82
Montana	126	34	160	40
Nebraska	1,380	677	80	30
Nevada	81	20	0	0
New Hampshire	624	178	0	0
New Jersey	839	206	20	5
New Mexico	450	171	114	28
New York	13,886	3,195	1,240	342
North Carolina	2,551	664	128	19
North Dakota	788	203	0	0
Ohio	5,964	1,464	1,183	436
Oklahoma	1,957	323	162	37
Oregon	3,098	515	588	136
Pennsylvania	4,980	1,421	543	162
Rhode Island	240	65	70	24
South Carolina	1,344	356	68	16
South Dakota	258	37	0	0
Tennessee	639	116	942	242
Texas	2,804	678	1,270	190
Utah	956	234	897	202
Vermont	349	126	8	2
Virginia	1,550	356	252	63
Washington	2,332	420	189	44
West Virginia	614	153	165	42
Wisconsin	3,552	958	1,333	201
Wyoming	211	54	0	0

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